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"KUMPTA" COTTON AND ITS IMPROVEMENT

BY

G. L. KOTTUR, B.Ag

Cotton Supervisor, Southern Division, Bombay Presidency

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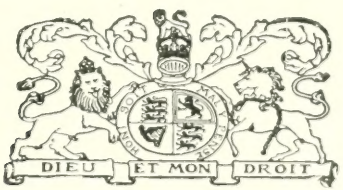

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KUMPTA COTTON AND ITS IMPROVEMENT.

BY

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[Received for publication on 5th November, 1919.]

I. Introduction.

One of the types of cotton most extensively cultivated in India is that strain or series of strains of *Gossypium herbaceum* which goes in the trade by the name of *kumpta*, or which, though called otherwise, is grown in adjoining tracts and is botanically and agriculturally indistinguishable from it. This cotton, which is variously known on the Bombay market as *kumpta*, *westerns*, *bagalkot*, *miraj*, or by many other names, belongs to one recognized botanical species, though the market value of the lint from various strains or mixtures of strains differs considerably, and though the agricultural value of these strains to the cultivators of the cotton is again by no means equal. It is the object of this memoir to give an account of the work done in the last few years in investigating the characters of the various strains of this cotton, as they occur in the cotton grown near Dharwar, and in isolating and developing types which have promise both from the point of view of the cultivators and of the trade. As the growing of types of *Gossypium herbaceum* as a commercial cotton is peculiar to southern and western Asia, and to the Mediterranean region, a short account of the characteristics of this species of cotton is prefixed before dealing with the special characters of the strains of *kumpta* cotton properly so called.

II. Gossypium herbaceum[1], Linn.

This species of the cotton plant, recognized from the earliest days of the classification of various cottons, seems to be almost entirely grown in southern

[1] In this discussion I am following Gammie's description of this species. Watt has named Gammie's *Gossypium herbaceum* as *Gossypium obtusifolium* var. *Wightianum* and considers that the true *Gossypium herbaceum* is a different species, identified with the so-called Levant cotton.

and western Asia.[1] It forms one of the chief cultivated cottons of India, and it is grown in China, and also in Persia. Beyond this, there is little or no clear or definite information. Gammie states that samples from Turkey, Greece, Armenia, Persia, Cephalonia, Crete, Khorasan, Afghanistan and Gilgit appear to belong to this species but then adds, "they may just as well be considered forms of *Gossypium obtusifolium*, Roxb."[2] In India, however, its cultivation is very widespread. Typical *Gossypium herbaceum* is grown as *lalio* in Kathiawar and Northern Gujarat, as *broach*, *surat*, *kahanmi*, *ghogari* in Gujarat, and as *kumpta* and the other commercial types mentioned above (*see* page 221) in the centre of Peninsular India. Types of the cotton plant distinguished by Gammie as separate varieties occur in the *mungari* or *bellai*, *uppam*, *northerns* of Cuddapa, as a mixture in *karunganni*, and one or two other kinds in Madras, and in the *wagad* or *sakalio* of Gujarat.

Gossypium herbaceum has been supposed by some to be a cultivated form of *Gossypium obtusifolium*[3] which is found wild in many places in the Southern Maratha Country (Badami, Gokak, etc.), and also in Sind. This wild plant is declared by Cooke to be a wild condition of *Gossypium herbaceum* var. *Wightianum*, or a hybridized form with perhaps *Gossypium neglectum*.[4] It is undoubtedly, however, *Gossypium obtusifolium* simply.

The botanical characters of the typical *Gossypium herbaceum* have been defined in detail by Gammie (*l.c.*). The most characteristic features from this point of view are the fact that the basal branches are long and spreading, which causes Leake[5] to class this species among the monopodial types of cotton. The corolla is yellow, with a black eye, fading to yellow suffused with red, somewhat larger than the bracteoles. The type is, in fact, well known, though systematic authorities are by no means yet in agreement as to the name which properly belongs to this species. Watt classes most of the *herbaceum* cottons under discussion as *Gossypium obtusifolium* var. *Wightianum*. The exact name given to the group of cottons, as defined by Gammie and others, is not perhaps an important matter.

There are, however, several characteristics of the various types known together as *Gossypium herbaceum* in cultivation, which are important in considering this type as an agricultural plant. They are as follows :—

[1] De Candolle considers that probably it was originally limited to the south and east of India.

[2] The distribution is well described in Watt's "Wild and Cultivated Cotton Plants of the World," pp. 143–153 (1907). *See* also Cooke. *U. S. A. Dept. Agric. Bur. Plant Ind. Bull. No. 88.*

[3] Dalzell and Gibson. "Bombay Flora," p. 8 (Supplement), 1861.

[4] Cooke. "Flora of the Presidency of Bombay," London, 1903, p. 117.

[5] Leake. *Journal of Genetics*, 1911, Vol. I, p. 209.

(*a*) The *herbaceum* cottons all have a somewhat long-growing period as compared with most of the other cultivated Indian types. When it grows normally, *broach* cotton is planted in June, and the picking is not complete till the following March. *Kumpta* cotton, planted usually in Dharwar in August or September, often is still ripening cotton bolls in the following May. The reason for this very long period of growth (or rather of boll production) will appear later, as a result of the occurrence of several different kinds of bolls on the plants.

(*b*) The seeds are always covered with fuzz,[1] the fuzz being white in this case, and the seeds are relatively large. The result of this latter point is that, compared with other cottons, the percentage of lint to the weight of the seed cotton (ginning percentage) is usually not very large. Taking a large number of samples examined by Gammie,[2] and not distinguishing varieties, the average ginning percentage works out with three fairly largely grown species as follows :—

	1902–03 Per cent.	1904–05 Per cent.
Gossypium herbaceum	29·1	29·4
Gossypium indicum	31·0	33·1
Gossypium neglectum	31·6	33·5

Of course, in each of these species the variation is large, and in each case there are strains with much higher ginning percentage than others. Thus among the *herbaceum* cottons the *ghogari* of Gujarat has a high ginning percentage, and the *kumpta* has a low one, and similar differences occur among the others. But, as a general rule, the *herbaceum* cottons have larger seeds and a smaller percentage than most other types of Indian cottons.

(*c*) The *herbaceum* cottons, as a rule, are far more bushy in habit than most other species of cotton. This is the result of their bearing a number of the so-called monopodial branches. The bushiness even among the *herbaceum* cottons varies very much indeed, and the differences among the strains are characteristic, as we shall see, of the varieties grown in different regions. But though these differences occur, yet even the less bushy strains of *herbaceum* cotton usually appear far more bushy than other species. Other cottons, in fact, bear their cotton almost entirely on sympodial branches; the *herbaceum* cottons bear their bolls also in large measure on the monopodia or on the axillary branches. One of the results of the fact that bolls are produced

[1] Except in one form of *herbaceum* cottons from Madras (*see* Gammie, *l.c.*).

[2] "Indian Cottons," 1905, pp. 21–28. Gammie now thinks (private communication to the author) that these figures should be revised and that *Gossypium indicum* has probably on the whole a lower ginning percentage than *Gossypium herbaceum*.

largely on three types of branches—monopodia, sympodia, and axillaries—which are developed at different stages of the plant's growth, is that the *herbaceum* cottons bear during a very long period, or, in other words, tend to ripen bolls over a good many months.

(*d*) The *herbaceum* cottons can, as a rule, be distinguished among other varieties by the light, rather yellowish, green colour of the leaves and stems. Other cotton plants are nearly all very much darker green in colour. So much so that a field of a *herbaceum* cotton looks almost unhealthy to anyone who has been accustomed to deal with other species of cotton.

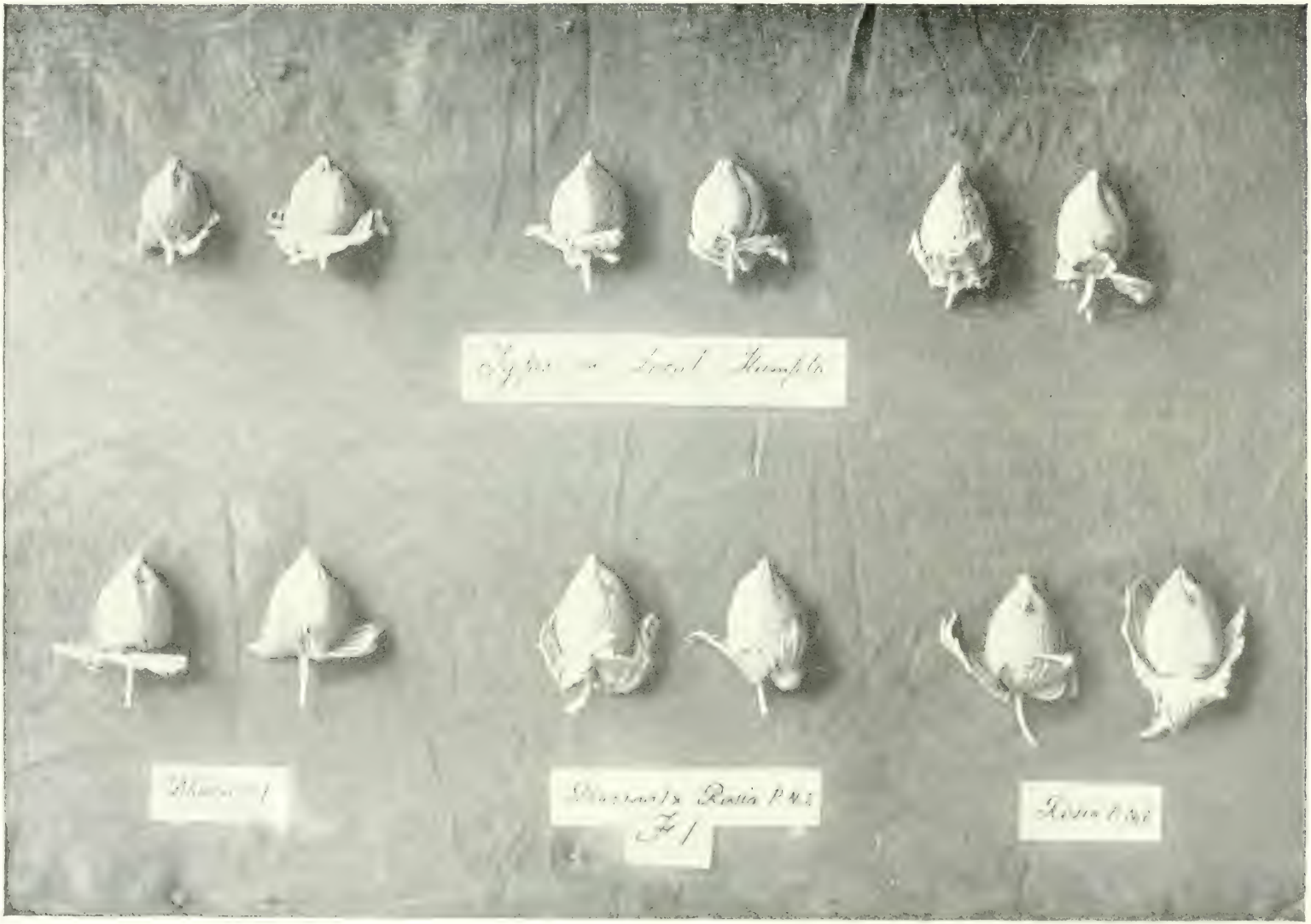
(*e*) The bolls of the *herbaceum* cottons are much rounder in shape than those of almost any other variety. This character will be seen in Plate I, where a number of types of bolls found in *kumpta* cotton are illustrated. But whether we have to deal with the small-bolled *kumpta*, or the much larger-bolled *herbaceum* cottons of Gujarat, the roundness of the boll is a feature of *Gossypium herbaceum*. This roundness varies a good deal, and there is a general belief among the growers that more elongated bolls tend to give a longer staple cotton than round bolls, but the correlation between these characters has never hitherto been investigated.

These various characters of the *herbaceum* cottons, when grown as agricultural plants mark them off from their congeners, tend to give a large crop of low-ginning cotton, and lead to the limitation of their distribution to places where a long-growing period is possible either on account of a well-distributed rainfall or irrigation, or on account of the absence of the likelihood of frost. Where the growing period can only be short, for whatever reason, other types of cotton tend to prevail which may not yield so well, but which ripen quicker, and which often, though not always, in India, give a cotton of inferior staple.

III. "KUMPTA" COTTONS.

One of the most important types of *Gossypium herbaceum* cultivated in India is that known commercially under the name *kumpta*, a name probably derived, as Mollison[1] notes, from the fact that much of the cotton produced in the *kumpta* tracts reached Bombay, in the pre-railway days, *viâ* the port of Kumpta in North Kanara. The name is more restricted than the type of cotton, and this latter spreads continuously over a very large area in the Southern Maratha Country of the Bombay Presidency, as well as into Mysore and the Nizam's Dominions. The attached map (Plate II) shows for the Bombay-British districts the intensity with which it is cultivated. It, however,

[1] "Textbook of Agriculture" (1902), Vol. III, pp. 200–201.



Types of boll in *Kumpta* cotton, and in a cross with *Gossypium neglectum*.

PLATE I.

reaches Bombay under various names among which *miraj*, *bail-hongal*, *bagalkot*, *westerns*, and many others are recognized. Except for a relatively small area in the eastern part of the Dharwar District and adjoining tracts where a form of *Gossypium hirsutum* is grown, known as Dharwar-American, it is the dominant cotton in almost all the area where it is grown, gradually disappearing, however, in favour of types of *Gossypium neglectum* in the north of the Bijapur District and portions of the Nizam's Dominions, and in favour of types of *Gossypium indicum* in other districts of the Nizam's Dominions.

The present paper is, however, almost wholly concerned with *kumpta* cotton as it occurs in the Dharwar District which, with the southern part of the Bijapur and Belgaum Districts, remains the head centre of its cultivation. This cultivation is probably of very old standing, though the descriptions of the local cottons grown seem to have interested few of the cotton workers of the last century. The reports of the older work on cotton in the Southern Maratha Country in the years between 1830 and 1870 are full of accounts of American cotton and the vicissitudes which attended all efforts to introduce it. They rarely, however, refer to the cotton already grown. It was apparently beneath notice, though it is, as a matter of fact, almost as valuable as that American for whose introduction so many pains were spent.

Since 1870, however, a few interesting notices of this cotton as cultivated in its own districts have been presented. Drury[1] in 1873 mentions that the yield may go up to 500 pounds per acre, presumably of seed cotton. The most interesting account of the cultivation of *kumpta* cotton, however, is that given by Walton[2] in 1880. He noted particularly that it is sown in August, and that earlier sowing has not been a success. He mentions that Dharwar-American cotton (which he calls *G. barbadense*) has replaced *kumpta* over parts of Belgaum and Bijapur. But the most interesting point he makes is that the cultivators object to manuring directly for *kumpta* cotton, an objection still maintained by the people. Watt[3] adds very few facts but notes that the area of *kumpta* cotton in the three districts of Dharwar, Belgaum and Bijapur was 1,118,250 acres in 1883, but had dropped to 968,300 in the years before 1890.

I may quote two or three other authorities who note various points about *kumpta* cotton, before going on to place my own observations on record. The

[1] "Useful Plants of India," 1873, p. 233.

[2] Walton, W. "Cotton in Belgaum and Kaladgi Districts," 1880.

[3] Watt, "Dictionary of Economic Products," Vol. IV, p. 59 (1893), and also "Wild and Cultivated Cotton Plants of the World," p. 150 (1908).

first of these is Middleton[1] who grew the *kumpta* cotton in Gujarat, and mentioned that, though grown side by side with Dharwar-American cotton for many years, it shows no trace of hybridization with it. Gammie[2] in 1905 gives a few further details with regard to distribution and specially remarks on the now well-recognized fact that the stiffer soils in the Bombay Karnatak are considered most suitable for *kumpta* cotton, while Dharwar-American cotton occupies the lighter lands.

Since the above, the remarks on *kumpta* cottons grown in the Bombay Karnatak are few and far between. The recent report[3] of the Indian Cotton Committee notes, however, as follows :—

"It may be mentioned that *kumpta* as is the case with other varieties of *herbaceum* is possessed of very stable characteristics and that it is therefore difficult to produce anything in the nature of a recognizable improvement in it. Recent researches have, however, shown that the quantity of the crop can be sensibly increased by a change in the mode of growth. Such a change can be brought about by a selection of an early maturing type, the characteristics of which are an upright habit of growth with many fruiting branches and few vegetative branches. This character is freely inherited, although it is sometimes masked by the check caused in the leading shoot by the borer which attacks its pith. The selections which are being made all conform to this type which furnishes a distinguishing mark capable of easy detection on the field, where plants of the bushy type are most prevalent. The more compact habit permits of closer planting and therefore results in a heavier crop."[4] "It is at its best in Belgaum but is almost equally good in Dharwar, falling off in quantity further eastward. It differs from the variety of *Gossypium herbaceum* grown in Gujarat in its shorter period of growth, smaller bolls, and lower ginning percentage, the latter being 26. The staple of the *kumpta* variety is $\frac{7}{8}$ inch in length."[5]

Present distribution of "kumpta" cottons in the Bombay Presidency.

The present distribution of *kumpta* cotton growing in British section of the Bombay Presidency is almost limited to three districts, Dharwar, Bijapur and Belgaum, though there is a little in Satara. In the first of these it shares the cotton area with the so-called Dharwar-American type, and to a less extent

[1] Middleton. *Agricultural Ledger No.* 8 (1895).
[2] Gammie. "Indian Cottons," Calcutta, 1905.
[3] "Indian Cotton Committee Report," 1919 (Calcutta).
[4] *Ibid*, paragraph 123.
[5] *Ibid*, paragraph 117.

in recent years with Cambodia, and with *broach* cotton. So far as the area under these last two cottons is concerned, there are no statistics available, but the area under *kumpta* and Dharwar-American cotton is separately recorded and is indicated below for the two types of cotton—

	"Kumpta" cotton		Dharwar-American cotton	
	Average area, 1908–12	Area, 1918–19	Average area, 1908–12	Area, 1918–19
	Acres	Acres.	Acres	Acres
I. Dharwar District ..	388,000	403,343	229,769	261,118
Talukas.—				
Dharwar ..	26,462	36,543	658	..
Hubli.. ..	39,650	24,725	19,298	32,826
Gadag ..	55,981	60,234	81,682	73,889
Ron.	23,869	49,125	74,346	43,502
Navalgund ..	65,159	99,063	16,842	22,215
Haveri ..	34,308	55,120	7,272	20,926
Ranebennur ..	20,769	14,856	29,862	40,937
Bankapur ..	41,287	30,218	..	16,706
Kalaghatgi ..	2,791	11,006	..	..
Hangal ..	8,367	10,250	..	1,837
Kod.	7,384	12,203	..	8,280
Mundargi ..	..	..	..	..
Nargund ..	33,433	..	..	..
II. Bijapur District ..	584,168	526,299	99,408	122,037
Talukas.—				
Badami ..	40,111	38,165	..	..
Bagalkot ..	78,815	95,825	315	..
Bagewadi ..	90,494	75,393	..	35,000
Bijapur ..	62,468	64,255	..	..
Hungund ..	81,919	77,129	9,465	32,809
Indi.	23,577	56,186	5,048	120
Muddebihal ..	1,38,788	49,346	21,411	48,897
Sindgi ..	62,422	70,000	564	5,211
III. Belgaum District ..	235,489	208,787	..	..
Talukas—				
Belgaum ..	3,450	4,727	..	..
Khanapur ..	92	86	..	..
Chandgad ..	..	..	..	..
Sampgaon ..	27,097	28,087	..	..
Parasgad ..	73,162	75,826	..	..
Gokak ..	40,232	37,879	..	..
Chikodi ..	13,044	11,843	..	..
Hukeri ..	6,359	9,046	..	..
Athani ..	71,898	41,293	..	..

The distribution of these two cottons is shown in the accompanying sketch maps (Plates II and III). The *kumpta* cotton is obviously the dominant cotton in these three districts. It is exclusively grown in Belgaum. In Dharwar, where the American introductions of the last century have taken deepest root, these latter vary between 34 and 39 per cent. of the cotton area. In Bijapur Dharwar-American cotton only occupies from 13 to 15 per cent. of the cotton area, and a small but indefinite amount of *Gossypium neglectum* and *Gossypium indicum* cottons are also grown in the north and east of the district. It will be seen that in the British districts of the Bombay Presidency only, there are over 1,200,000 acres under this cotton on the average.

The tract in which it will be seen from these figures that *kumpta* cotton is cultivated, possesses features of climate and soil which distinctly mark it off from most other Indian cotton areas, and which seem to be peculiarly favourable to the types of *Gossypium herbaceum* which go by this name.

Soils of the kumpta tract. First with regard to soil. We are here at the southern extremity of the great area of black cotton soil derived from the Deccan trap. In fact it is in this region that the Deccan trap disappears, and the soils derived from it are replaced partially or wholly by those resulting from old sandstones and quartzites in the Belgaum and Bijapur Districts and from shales and schists in the Dharwar area proper. The soils are, therefore, very variable. Where the soil is chiefly a highly decomposed trap soil, it is usually very stiff and clayey ; where it is entirely derived from the other rocks mentioned it is usually light in character ; while where there are mixtures of the two it has an intermediate character. The *kumpta* cotton is almost entirely restricted to the deep black almost pure trap soils, and to the medium black soils which consist of a mixture of trap soil with that derived from the other rocks. In other words, it is restricted most largely to the stiffer kinds of land. This is also largely true, though not to the same extent, of Dharwar-American cotton, for this latter is also grown and yields well on some of the red soils of southern part of the Dharwar District. So far as the *kumpta* cotton is concerned it seems universally found that under the climatic conditions found in the area under discussion, a shallow or light soil means a poor outturn and a low ginning percentage. In other words, the yield and ginning percentage both fall off as the soil becomes less retentive of moisture.

Rainfall of the "kumpta" tract. The districts in which *kumpta* cotton is grown can be divided, so far as rainfall is concerned, into three areas. To the

(Each dot represents 100 acres of Cotton. Cross-hatched areas are Native States.)

(Each dot represents 100 acres of Cotton. Cross-hatched areas are Native States.)

west, there is the so-called *malnad* tract, with heavy rainfall, light soil, and practically no cotton. East of this lies the typical *kumpta* area, where in the east of the Belgaum District and the centre of the Dharwar District lies the transition tract, where rainfall, as typified by Dharwar itself, amounts on the average to 30 to 35 inches per annum. The actual average at Dharwar for a period of forty-three years is 32·7 inches. To the east of this section lies a drier tract where *kumpta* cotton is still grown, embracing the greater part of the Bijapur District and the east of the Dharwar District. Here the average rainfall is usually below 25 inches per annum. At Gadag, a typical centre, the annual average rainfall for forty-three years has been 24·9 inches.

The striking feature of the rainfall in the *kumpta* tract is not, however, the total amount, but rather its distribution. This distribution extends over a much larger period of the year than is the case in most Indian cotton districts with the exception of those of the south of the peninsula. The most frequent amount of rain received in each month (the 'mode'), at the two typical centres above named (Dharwar and Gadag), is as follows, taken from the records of forty-three years :—

	Dharwar (Transition tract)	Gadag (Dry tract)
	Inches	Inches
January	..	..
February	..	..
March	0·5	..
April	1·5	1·0
May	2·5	2·0
June	5·0	2·5
July	5·0	2·5
August	4·5	1·0
September	1·5	5·0
October	3·5	3·0
November	0·5	0·5
December	..	..

This distribution of rainfall is shown in Text-figure 1. In Dharwar there is substantial rain from May to October, and often some in April also, the

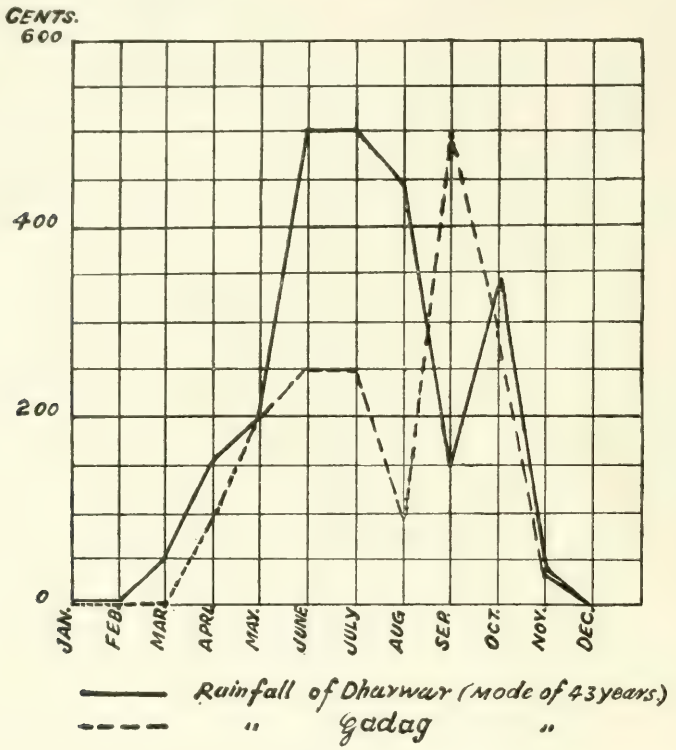
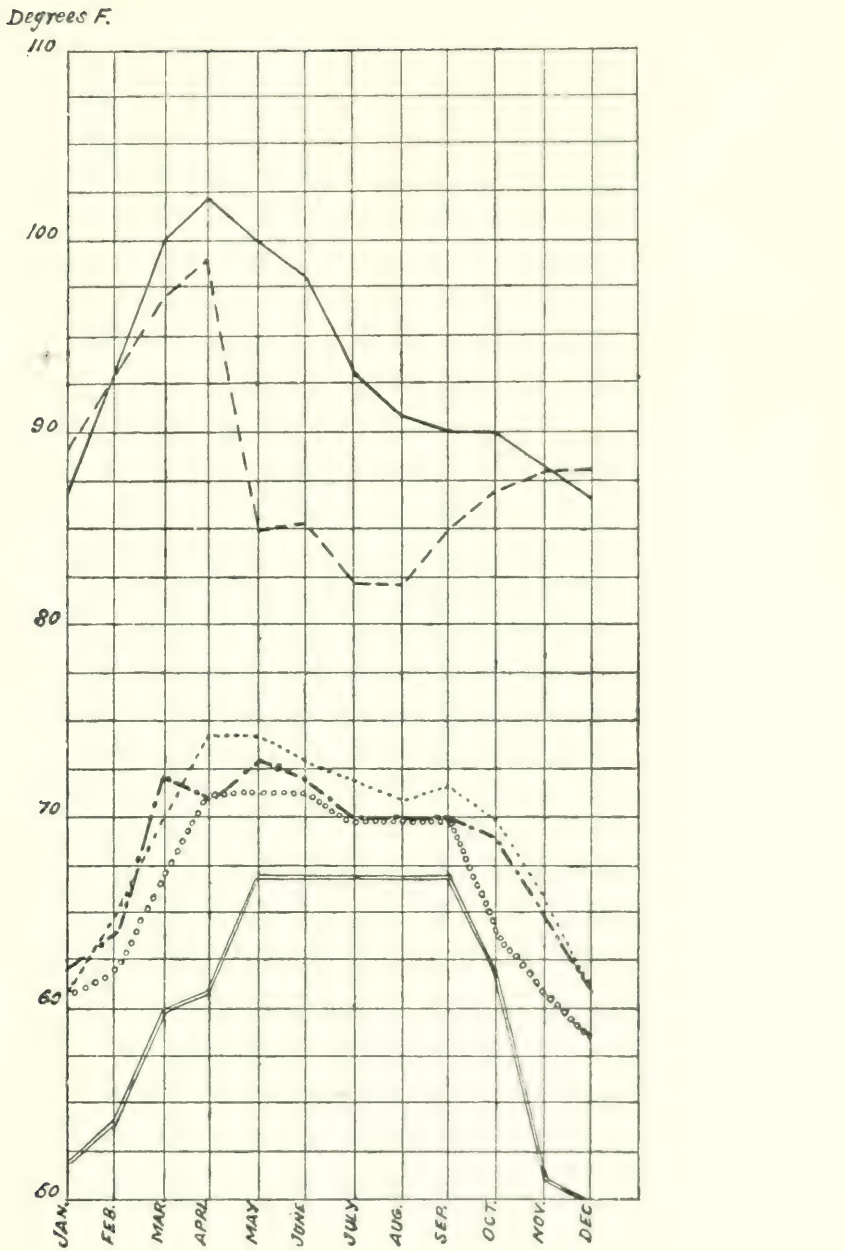


Fig. 1.

heaviest rain coming before sowing, and giving a thoroughly saturated seed bed for sowing the cotton in August. In Gadag the heaviest rain comes later—in September—but the rainfall is, nevertheless, fairly well distributed during the months from May to October.

Temperatures in the "kumpta" tract. The portion of the district I have named the transition tract above is temperate; the drier area to the east is very hot during March, April and May. The variations in the maximum and minimum temperatures from month to month are well shown in Text-figure 2. The generally higher temperature of the eastern drier tract is very obvious, and this is most marked in the months from May to August. From a cotton growing point of view, however, the most striking feature is that the average minimum temperature for the whole year in both cases is above 60°F. This enables cotton to be growing through the cold weather, and, in fact, over the whole of this tract the *kumpta* cotton grows throughout the coldest part of the year. The absolute minimum temperature during 20 years was 50°F.


Degrees F.
110
100
90
80
70
60
50
JAN.
FEB.
MAR
APRL
MAY
JUNE
JULY
AUG.
SEP.
OCT.
NOV.
DEC
Average Maximum of Gadag (Dry tract)
" Dharwar (Transition tract)
Average Minimum of Gadag (Dry tract)
" Dharwar (Transition tract)
Absolute Minimum Gadag.
Absolute Minimum Dharwar.

Methods of growing "kumpta" cotton. Although there are few peculiarities in the cultivation of *kumpta* cotton, a few words may be said with regard to it. The land is prepared for cotton by ploughing with the wooden plough, which generally goes three to four inches deep or a little more. The first ploughing is done after the fall of one or more good ante-monsoon showers in April or May. During the early part of the rains, the land is simply harrowed once or twice and any stubbles of the previous *jowar* (*Sorghum vulgare*) thus removed. The seed is sown at the rate of seven pounds per acre in August or September. The second half of August is the most common time. The usual method of sowing is to drop it in the furrows of the drill, through bamboo tubes attached to the tines. The method is rather more expensive and less effective than drilling, even using the ordinary country drill of Gujarat. The distance between the rows varies from eighteen to twenty-one inches, except in some parts of Bijapur where it is twelve inches. The distance between the plants is very irregular, as no thinning is done to regulate it.

The rotation used is a two-course of *jowar* and cotton, or a three-course of *jowar*, cotton and wheat. Whichever is adopted the *jowar* alone is manured,* generally with five to six cartloads (about 2 tons) of cattle manure per acre.

The cotton is ready, usually, for the first picking in February, and three four, or five pickings at intervals of ten to fifteen days are needed to harvest the *kapas* (seed cotton). Belated bolls continue to be produced until the end of April or the beginning of May. The average yield of *kapas* in the *kumpta* districts is about 350 pounds of *kapas*, equal to ninety pounds of clean cotton lint, but there are many farms where 600 pounds of *kapas* is normally obtained.

IV. Variations in "kumpta" cotton.

Kumpta cotton differs from other types of cultivated *Gossypium herbaceum*, and notably from those grown in Gujarat in several particulars. In most of these, however, it is much more closely allied with the *herbaceum* cottons of Madras than with those of the north of the Bombay Presidency. The main points of difference with these last are as follows :—

(1) *Habit of growth.* The Gujarat *herbaceum* cottons (*broach, lalio, ghogari*) are bushy, that is to say, the normal type produces a number of vigorous monopodia. These are much less abundant in *kumpta* cotton, and hence by the side of the others, it appears to be erect and to possess much less of the bushy character. As we shall see, this quality varies very much in the various strains of *kumpta*, but the difference between the predominant type in the two cases cannot be mistaken.

* It is usually considered very bad practice to manure the cotton crop itself.

(2) *Length of growing period.* All *herbaceum* cottons, as I have noted before, have a long growing period, but there is a great difference in the actual average length in the cotton grown in different regions. The *herbaceum* cottons of Gujarat have a growing period longer by two months than *kumpta*. The former are usually planted in June : the *kumpta* is sown in August-September as above noted. But the crop is obtained at about the same time, that is to say, in February and March.

(3) *Leaf fall.* Another marked point of difference is the way in which the *kumpta* cotton plants lose the greater part of their leaves at the beginning of the cold season. This does not occur with the *herbaceum* cottons of Gujarat. It is not a matter of climate, for the Gujarat cottons do not drop their leaves when grown in the *kumpta* region.

(4) *Size of boll.* The Gujarat *herbaceum* cottons have a large round boll quite distinct from the much smaller, slightly tapering boll of the *kumpta* cotton. Various types of this latter are shown in Plates I and VII.

(5) *Colour of cotton.* Another very marked feature is the different colour of the cotton lint. The *kumpta* cotton has always a dull colour with a tinge of red in it. The Gujarat *herbaceum* cotton, on the other hand, is very white and much brighter in colour.

(6) *Ginning percentage.* The usual ginning percentage of *kumpta* cotton is very low. In this feature, *herbaceum* cottons differ very much indeed, and the various types vary from 40 per cent. or more in the *ghogari* of Gujarat to 32 or 33 per cent. in *broach* cotton, and to 25 or 26 per cent. in *kumpta* cotton. Of all the cultivated types of *Gossypium herbaceum*, *kumpta* cotton has the lowest ginning percentage.

(7) *Seed characters.* The *herbaceum* cottons of Gujarat have as a rule large and very fuzzy seeds. The seeds of *kumpta* cotton, on the other hand, are smaller and much less covered with fuzz. The difference is again very characteristic, and enables the seeds of the two types to be at once distinguished.

While these features enable *kumpta* cotton to be easily differentiated from the *herbaceum* cottons of the more northern parts of the Bombay Presidency, it is not suggested that either one or the other, or in fact any variety as usually cultivated, is a single definite type. It has often been said that *kumpta* cotton is possessed of very stable characteristics. This has, in fact, been repeated (*vide supra*) in the recently issued report of the Indian Cotton Committee. But I have found it extremely variable and to consist of a large number of distinct strains with different cultural, botanical and commercial characters. True, the differences found are perhaps not so great as those

among the cultivated types of *Gossypium neglectum*, but the differences are, nevertheless, very great, and not only does the cotton grown in different places vary very much, but the plants in any field have markedly distinct characters.

Some plants, for example, grow tall, bearing hardly any monopodia, and almost exclusively sympodial branches; others bear a large number of monopodia. These two types are in marked contrast to the eye, the former giving an open plant and the latter one which appears crowded with leaves. Following the difference in form is a difference in ripening. The plant predominantly sympodial usually ripens early and uniformly; the plant with a large number of monopodia is late and irregular in ripening. The bolls in different plants vary much in size, a difference which is of considerable commercial importance, as large bolls mean more *kapas* from each boll. The shape of the bolls also differs much (Plates I and VII), though the differences are difficult to describe in words. Even illustrations do not fully show the variations in roundness and flatness which are easily recognized in the field.

The range of variations in an ordinary field of pure *kumpta* cotton hence became a matter of very considerable interest, and the following are the results of a study of this point conducted on cotton grown on the Government farm at Dharwar. The usual plan adopted was to take a large number of plants at random, and measure each character whose variation it was desired to test. The plants used for this purpose were never less than one hundred, and often numbered a thousand. These measurements were then plotted on a frequency curve in the usual manner. In this manner I have studied the variation in (1) the branching character of the plant, (2) the shape of the lobes of the leaf, (3) the shape of the bracteole, (4) the length of the flower petals and the length of the style, (5) the number of cells in the bolls, (6) the number of ovules in the cells, (7) the ginning percentage, (8) the weight of the seed, and (9) the average staple of the cotton on the seed. The results of these studies may now be given.

(1) *Branching of the cotton plant.* As has already been stated, cotton plants can be described as erect or bushy, when their difference in branching is considered. The bushy cottons bear a number of long vegetative branches or monopodia near the base of the plant, which spread out and cause the plant to cover a considerable area like a bush. In the erect cottons these monopodia are either entirely absent or their number is reduced. In this case most of the branches present are the so-called sympodia or fruiting branches. The bushiness of the plants is, therefore, measured by the number of monopodia on the plant.

A record of this number for 979 plants is as follows. The plants were taken at random, except that plants whose main stem was injured by insects were avoided :—

Number of monopodia	..	Number of times occurring ("Frequency")
1	..	0
2	..	82
3	..	268
4	..	199
5	..	311
6	..	93
7	..	17
8	..	9

A curve showing the frequency distribution of the branching character among the plants in a normal field of *kumpta* cotton at Dharwar is shown below (Fig. 3).

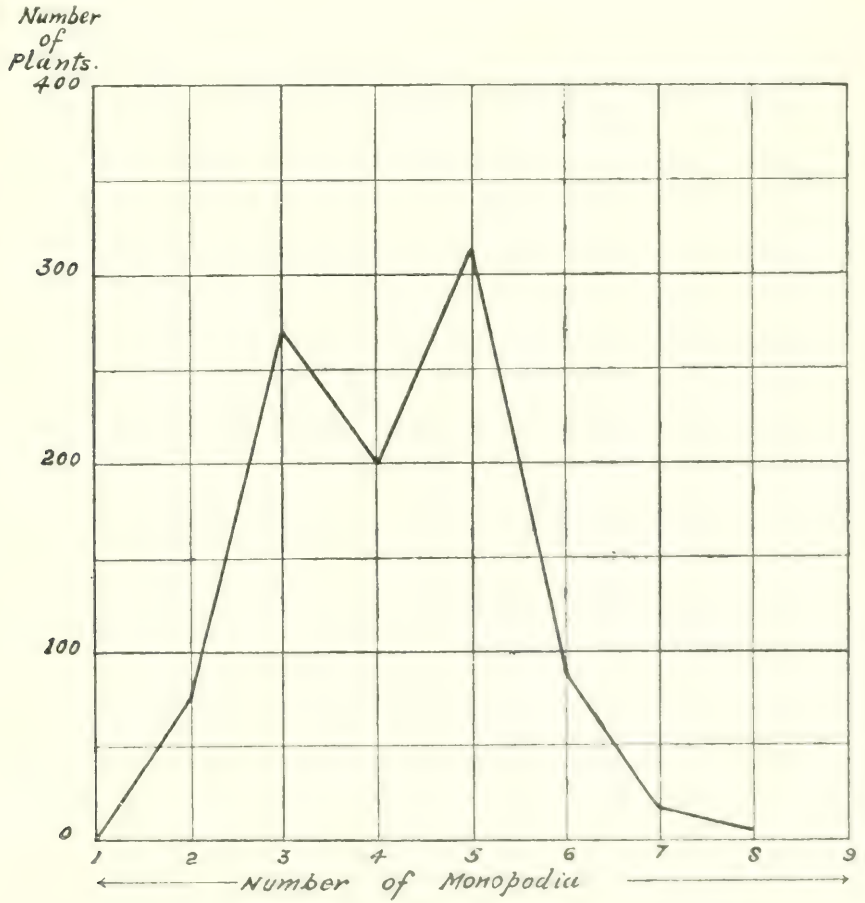


FIG. 3.

The curve, it will be seen, shows two points of very great frequency, one where the plants have three monopodia, the other where there are five, the latter being a little the more common. The mean number of monopodia is 4·15.

Such a multimodal curve means in this case, probably, that there are a number of different strains of cotton intermixed, with different tendencies to form monopodia. This probability is made almost into a certainty by a consideration of the variation in other characters.

(2) *The shape of the lobes of the leaf.* The lobing of the leaves is often regarded as a useful character in classifying cottons, and in most descriptions of species and varieties the shape and size of the lobes is usually referred to. Leake[1] was the first, however, to introduce any system of recording this character by measurement, and his 'leaf factor' was intended to supply the necessary accurate expression of the depth of the leaf indentations combined with the width of the lobes. It consisted in the maximum length of the leaf from the tip of the central leaf lobe to the base of the petiole (l), minus the distance from the bottom of the adjoining indentation to the base of the petiole (l^1), divided by the maximum breadth of the central lobe (b). It is indicated, in fact, by the expression $\frac{l-l^1}{b}$. This, as Leake remarks, is a purely empirical figure, but nevertheless, affords a useful means of indicating the shape of the leaf. I have obtained almost the same figure by simply measuring the length of the central lobe of the leaf and dividing it by the maximum breadth of the lobe.

Certain precautions are obviously necessary in the case of all such measurements. A primary leaf on the main stem differs much from the secondary leaf on the branches of the same plant. The primary leaves on any one plant, however, vary very little with the exception of the first three. These are in many cases abnormal, showing a smaller number of divisions than the remaining leaves on the plant. To secure uniformity of method, however, all measurements were taken on the sixth, seventh, or eighth leaf from the base of the stem.

Before giving the actual figures obtained in measuring the length and breadth of the middle lobes of such leaves of *kumpta* cotton, I may say that a simple experiment in crossing between two pure lines, breeding true, which I had isolated, indicates that in the length and breadth of the lobes of the leaf we are dealing with two simple Mendelian factors. It was found, in

[1] *Journal of the Asiatic Society of Bengal*, Vol. IV, No. 1 ; *Journal of Genetics*, Vol. I, No. 3.

fact, that a long middle lobe is dominant over a short one, and a broad lobe is dominant over a narrow one. A strain bearing leaves with long and narrow lobes was crossed with another bearing short and broad lobes. In the F_1 generation all the plants had long and broad lobes. In the F_2 generation a splitting occurred, giving plants in the proportion of twenty-seven plants with long and broad lobed leaves, nine plants with long and narrow lobes, nine plants with long and broad lobes, and three plants with short and broad lobes. This would seem to suggest the unwisdom of combining the measurements of length and breadth into one factor. I, therefore, submit the actual measurements of leaves (selected as above described) from one thousand plants in one field, grown under identical conditions of climate, soil, manure and cultivation.

Breadth of central leaf lobe.

Breadth of central lobe in millimeters		Number of times occurring ("Frequency")
27 — 30	....	61
30 — 33	....	198
33 — 36	....	271
36 — 39	....	252
39 — 42	....	128
42 — 45	....	71
Over 45	....	19
	Total ..	1,000

Length of central leaf lobe.

Length of central lobe in millimeters	....	Number of times occurring ("Frequency")
39 — 42	....	22
42 — 45	....	21
45 — 48	....	77
48 — 51	....	250
51 — 54	....	158
54 — 57	....	222
57 — 60	....	120
60 — 63	....	62
63 — 66	....	9
Over 66	....	39
	Total ..	1,000

Curves showing the frequency distribution of the various breadths and lengths of the central leaf lobe among the plants in a normal field of *kumpta* cotton at Dharwar are shown below (Fig. 4).

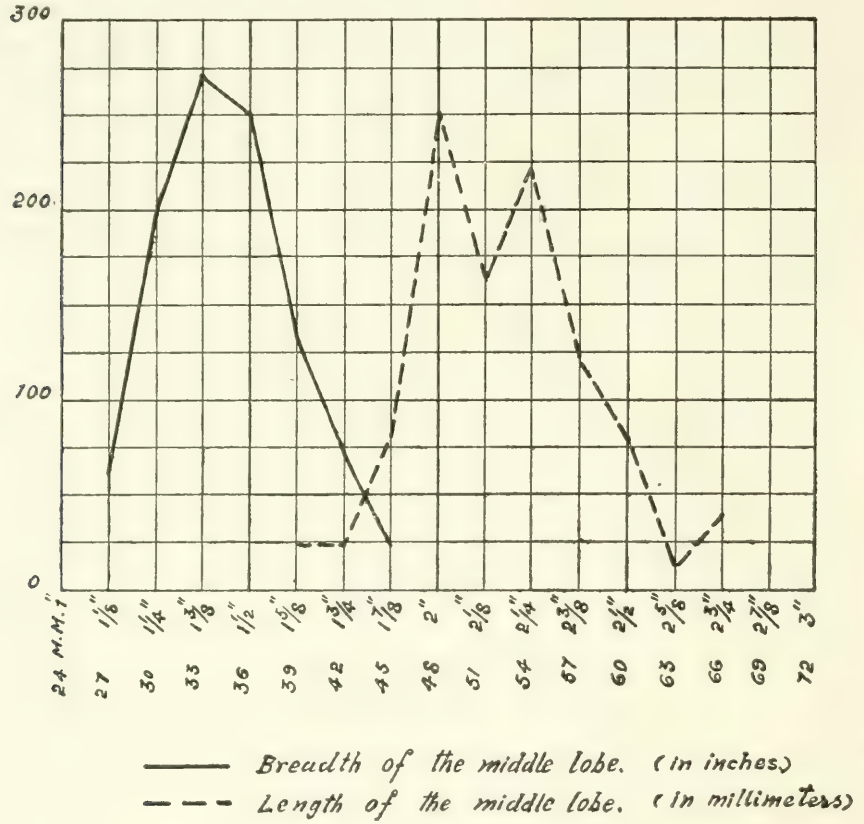


FIG. 4.

The mean breadth of the central lobe is 34 mm., the mean length is 52 mm.*

The curve of length is multimodal. The curve of breadth is also, in all probability, not simple. These, therefore, confirm the conclusion previously derived from a consideration of the branching that we have not a single varying type, but a mixture of several strains with differing characters in this respect. The figures, however, show the extent of variation in these factors which may be expected in *kumpta* cotton grown under identical conditions.

(3) *The shape of the bracteole.* So far as a preliminary study by crossing can indicate, the bracteole behaves very similarly to the middle lobe of the leaf, and the length and breadth of the bracteole seem to behave as simple

* I count in each case the lower width or length in each group of measurement as typical of that group.

Mendelian factors. A long bracteole is, in fact, dominant over a short, and a broad one is dominant over a narrow one. The number of teeth, and their arrangement and incision varies much on the same plant. The teeth vary from four to eight, and there is often some difficulty in finding out the rudimentary projections, which have to be separately counted. It is hoped to study the variation of these bracteole characters further, now that pure lines have been obtained, and have been crossed.

The variation in the length and breadth of the bracteole of open flowers on different *kumpta* plants is as follows :

Length and breadth of bracteoles.

Millimeters	"Frequency"	
	Length of bracteole	Breadth of bracteole
12 — 15	31	110
15 — 18	278	382
18 — 21	190	408
21 — 24	391	99
24 — 27	78	..
Over 27	32	..

The attached frequency curve (Fig. 5) shows that the extent of variation is not very wide. The mean length of the bracteole is 18·9 mm., the mean breadth is 16·5 mm.

Again the curve of length of the bracteole is multimodal, and that of the breadth shows evidence that it might also be so in reality. The conclusion from this is again in accordance with what has been noted for the previous factors measured.

(4) *The flower characters.* Perhaps the two most important characters in the cotton flower, from a breeding point of view, are the length of the petals, and the length of the style. The petals may be, in extreme cases, small and almost closed in the folds of the bracteoles, or they may be large and very prominent. In *kumpta* cotton, however, they are always large, showing only a small amount of variation.

The length of the style, likewise, varies much in different varieties, and in the extreme case of some tree cottons, it projects over an inch above the staminal column—in which case the chance of cross-pollination is very great. The stigma of the soft Peruvian tree cottons may often be seen without a single grain of pollen on it for a long time after the opening of the petals. It is probably on this account that no two plants of this variety agree in their characters, and the variation is very great. A short style will, on the other

hand, probably diminish the amount of natural crossing by securing fertilization as soon as the anthers burst open.[1]

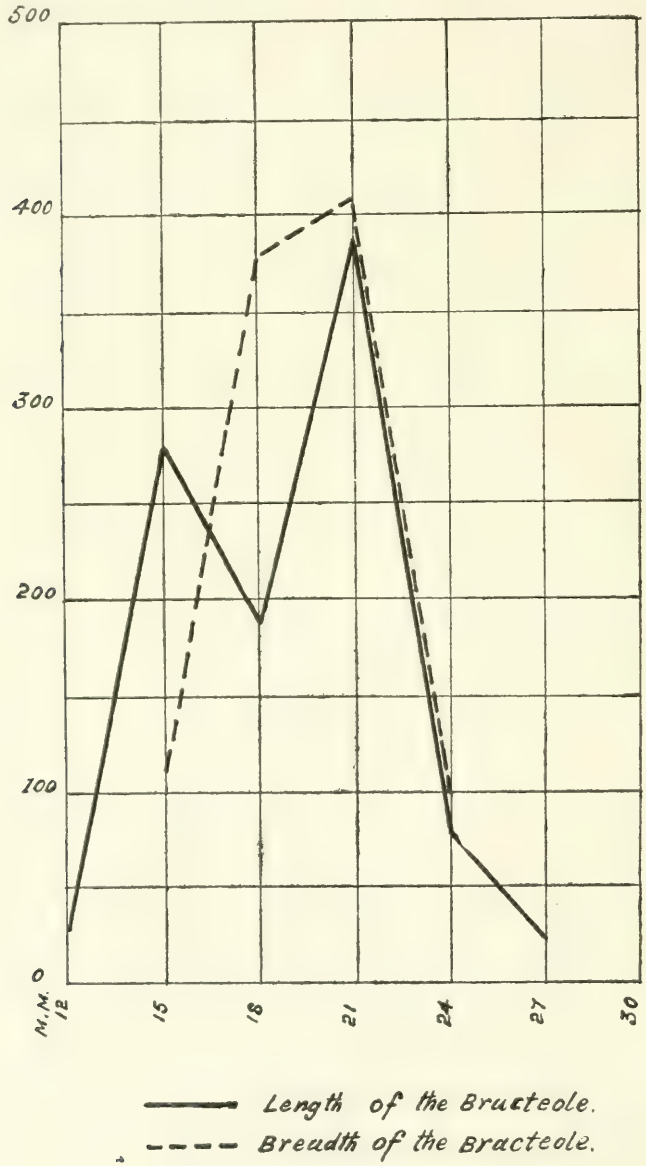


FIG. 5.

[1] Lawrence Balls ("Cotton Plant in Egypt," pp. 118-119) has studied this subject in some detail, but his conclusions that the length of the style is a minor factor in natural crossing probably requires to be revised under different conditions.

The range of variation of the above flower characters is shown by the following figures based on one thousand flowers :—

(a) Length of petals.

Millimeters		Frequency
12 — 15	....	159
15 — 18	....	142
18 — 21	....	229
21 — 24	....	320
24 — 27	....	121
Over 27	....	29

Here again we have a very wide variation and clear illustrations of a mixture of strains with different lengths of petals. The mean length is 18·6 millimeters, but with such a mixture of strains the mean ceases to have much value. The interesting figures would be the correlation between the length of the petals and of the bracteoles, and this will be determined in a further study of this question. A curve embodying the above figures is shown below (Figs. 6 and 7).

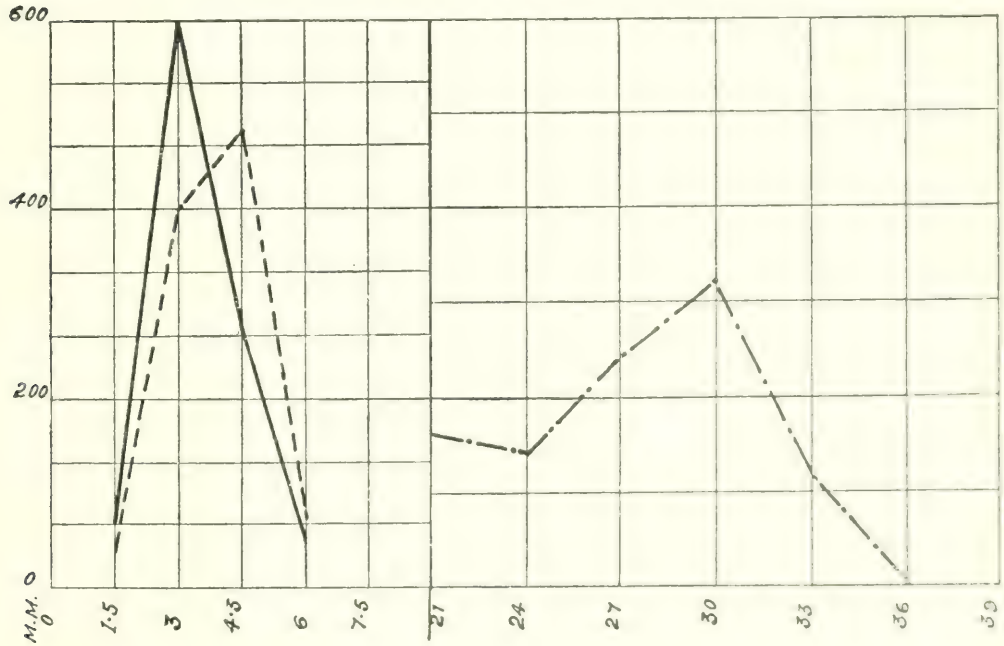


FIG. 7 FIG. 6.

(*b*) *Length of style.* The measurement taken was that of the projection of the style beyond the central column, in the flowers of *kumpta* cotton, and these figures are taken from a thousand examples.—

Millimeters		Frequency
1·5 — 3·0	....	48
3·0 — 4·5	....	402
4·5 — 6·0	....	479
Over 6·0	....	71

Here there appears to be less variation than in most of the previous characters studied. If we count the curve as a simple one then the standard deviation is seen to be 1·043 and the co-efficient of variability 0·274. The mean length of the style beyond the central column is 3·86 millimeters.

(5) *The boll characters.* I have already described the *kumpta* cotton as one bearing small bolls, with a tapering beak. The size and shape are subject to variation like other characters, not only on different plants, but on the same individual. The variations from the normal are widest during the last stage of growth, when the plants generally suffer from heat and drought. So far I have not been able to devise numerical expressions for denoting these variations, but they deserve careful study.

The other characters which are important are the number of cells in each boll, and the number of ovules in each cell. With regard to the number of cells in the boll, the number varies from two to six, although a greater range is possible. The actual variation is, however, very slight indeed in *kumpta* cotton, nearly all the bolls examined containing three cells. The following table shows the frequency of the various numbers of cells in 1,000 bolls examined :—

Number of cells		Frequency
2	....	2
3	....	987
4	....	11
	Total ..	1,000

I may note here that this constancy is not so great with other types of Indian cotton. In the well-known "N. R." variety of *Gossypium neglectum*, while the predominant number of cells per boll was still three, there was a larger number of bolls with four cells, the proportion being 160 in one thousand

bolls. The condition for *kumpta* and for "N. R." cotton is shown in the following curve (Fig. 8).

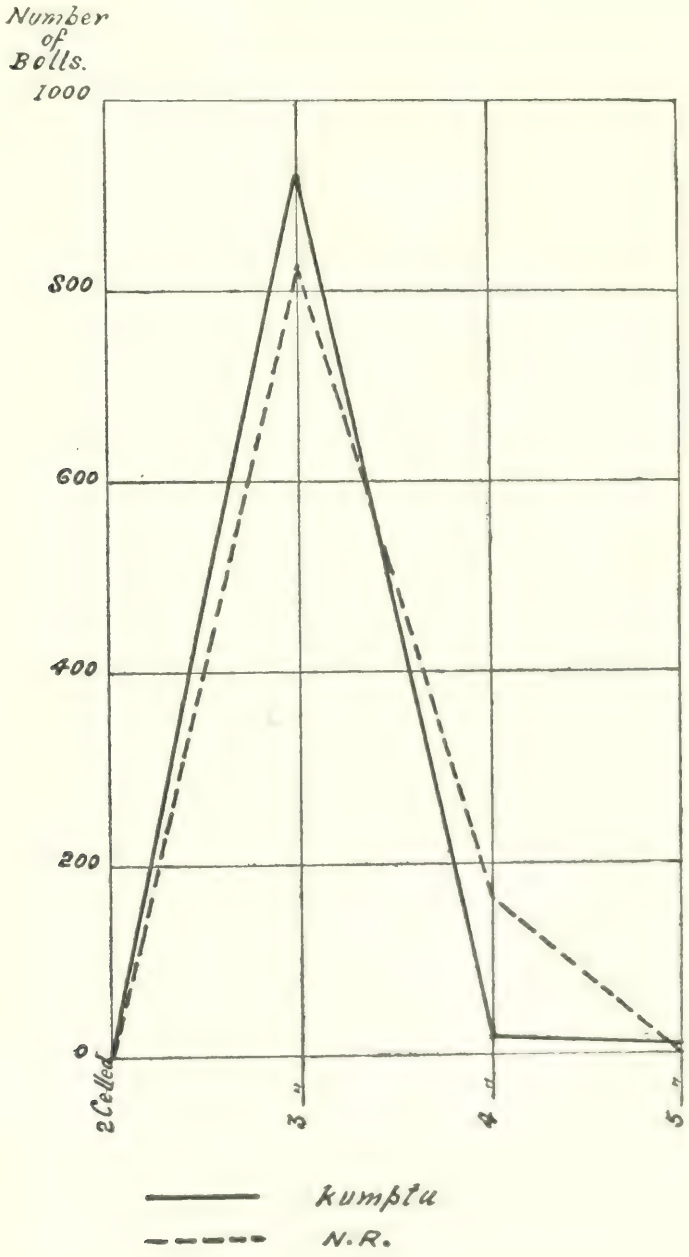


FIG. 8.

It may be here noted that among all Indian-grown cottons that I have examined, except acclimatized American and Cambodia, the three-celled boll is predominant. Among American varieties belonging to *Gossypium hirsutum* four to five-celled bolls are the most common.

The number of ovules in the cell varies from five to eight and this character is somewhat variable. The most common number is seven, which occurs in about sixty per cent. of the cases. Few cells (about 4 per cent.) contain five ovules. Still fewer (about one per cent.) contain eight ovules. The ovules are arranged one above the other in two rows. These rows contain four and three when there are seven ovules in the cell, contain four and two or three and three when there are six ovules in the cell, and contain three and two when there are five ovules. The cells containing eight ovules often show a different arrangement, into three rows containing 4, 3 and 1 or 4, 1 and 3. These arrangements are illustrated in the figure below (Fig. 9).

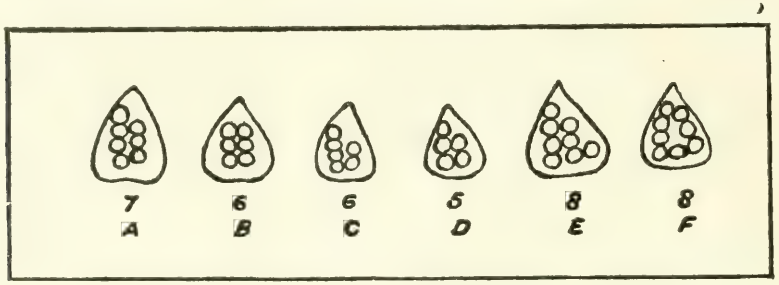


FIG. 9.

The actual frequency of each number in one hundred examples is shown by the following figures :—

Number of ovules per cell		Frequency
5	....	4
6	....	35
7	....	60
8	....	1
	Total ..	100

The importance, from the point of view of yield, of the number of ovules per cell of the boll is hardly capable of being appreciated on the present data. At first sight it would seem that a large number of ovules per cell will probably mean a big boll and large yield. Whether this is so, will be a matter for further study.

(6) *Ginning percentage.* Among the most important characters in determining the suitability of a cotton for cultivation is the ginning percentage,

that is to say, the proportion of lint to seed cotton. I have already said that *kampta* cotton on the average has a very low ginning percentage, but the actual figures vary very widely within the type of cotton. Some plants give as low a percentage as 18, others as high as 30. The average is usually considered to lie about 26, but in one hundred plants taken at random on the Dharwar farm the mean percentage was 23·6. The actual figures were as follows :—

Ginning percentage		Frequency
18	....	1
19	....	2
20	....	9
21	....	12
22	....	19
23	....	11
24	....	14
25	....	9
26	....	6
27	....	7
28	....	1
29	....	8
30	....	1

The curve which follows (Fig. 10) illustrates still more clearly the very wide variation.

Of course it must always be recognized that the ginning percentage is the product of a complex of factors, including season, climate, soil, and luxuriance of plant, and that the variety or strain is only one of these factors. But when plants are grown under identical conditions in the same field, a curve like that shown below can hardly be due to anything except a complicated mixture of strains yielding cotton of widely different ginning capacity.

(7) *Seed weight.* The weight of the seed is an important character in cotton, as it has a bearing on the yield and ginning percentage. Cooke[1] points out that lighter seeds raise the percentage of lint, as is indeed obvious, and at first sight it would suggest that the aim of a cotton-breeder should be to reduce the seed weight. But the evidence at present in hand seems to indicate[1] that there is a high positive correlation between the seed weight and lint weight. Though this statement needs confirmation as applied to Indian cottons in general and to *Gossypium herbaceum* in particular, yet in the meantime, considerable interest attaches to the variation in the seed weight of the cotton we are studying.

[1] Cooke. *U. S. A. Bureau of Plant Industry, Circular No. 11.* Tait, L. "Cotton Industry in Egypt," pp. 86 and 101.

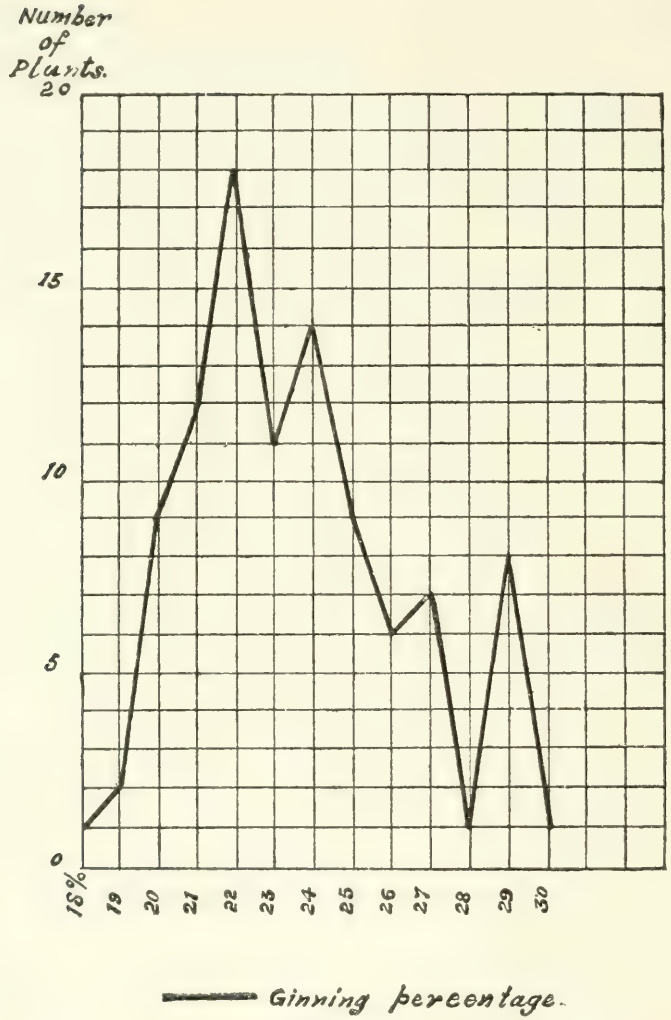


FIG. 10.

The variation in weight of 1,000 seeds from a single field, the cotton hence being grown under identical conditions, is shown in the following figures :—

Seed weight in grams		Frequency
0·025	...	10
0·030	....	29
0·035	....	9
0·040	....	11
0·045	....	32
0·050	....	172
0·055	....	410
0·060	....	101
0·065	....	118
0·070	....	42
0·075	....	39
0·080	....	20

The average weight per seed is 0·055 gram, and this is identical with the mode. The variation is very wide. If we may consider this array as simple, then the standard deviation would be 0·0028, and the co-efficient of variability 0·051. The variability is hence very high. I propose to study the correlation between the lint percentage and seed weight, and so determine whether the conclusions of Balls in Egypt in this matter are valid for *kumpta* cotton. The attached curve (Fig. 11) illustrates the variability of the seed weight.

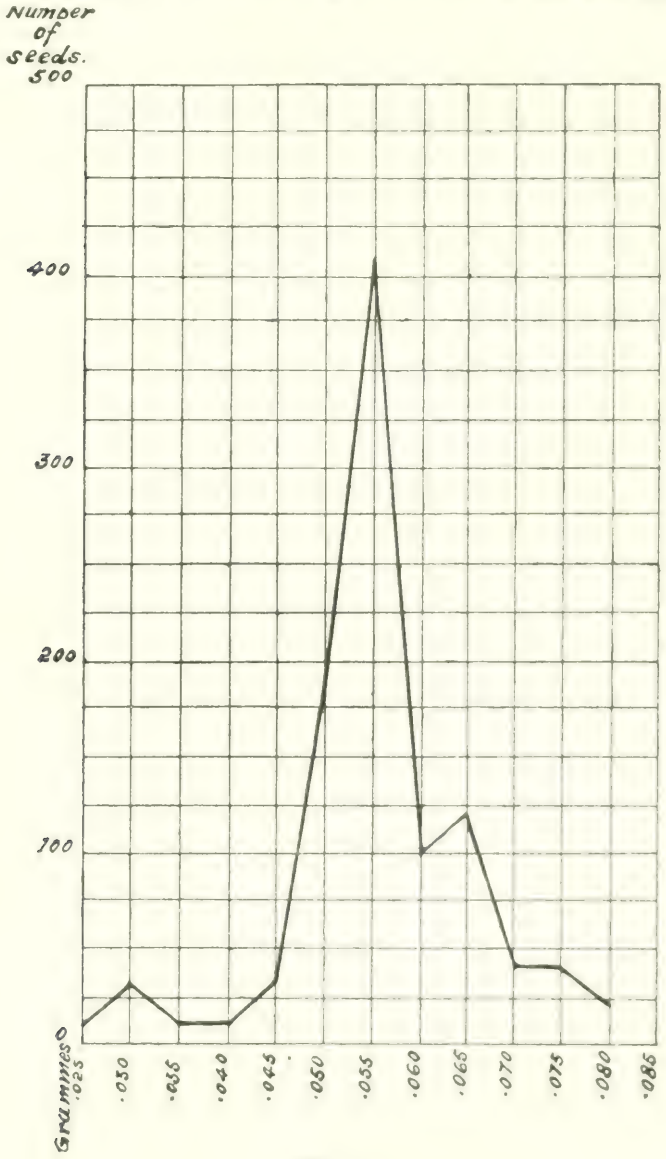


FIG. 11.

(8) *The staple.* The lint of *kumpta* cotton is markedly variable in staple and in strength. The length of the lint may be anything from half an inch to one inch, and the strength from very weak to strong. The variation in the length of staple has been studied on seed cotton, and the method is that used by Balls.[1] Seven seeds of each plant were combed and the length of fibres coming from the middle portion of the seed measured. Generally, the tip of the seed bears short hairs and the butt end bears long ones. The difference between the length at the tip and the butt of the same seed is often as great as six millimeters ($\frac{1}{4}$ inch). This is illustrated in Fig. 12.

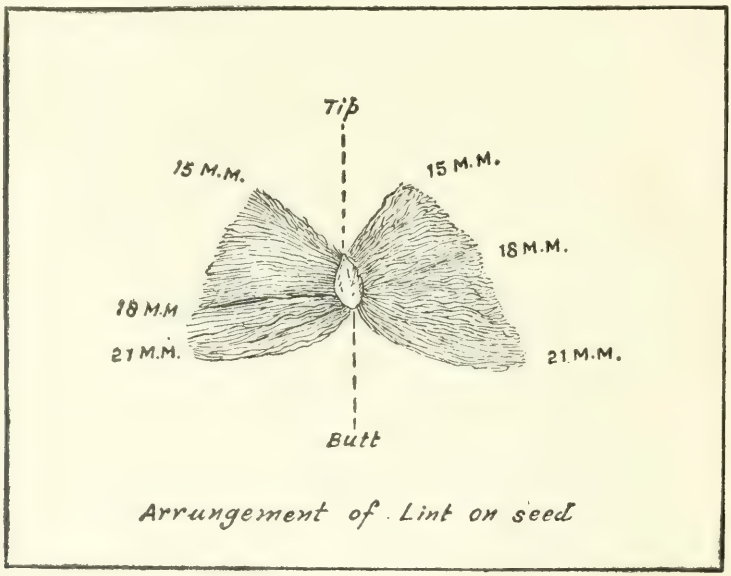


FIG. 12.

The bulk of the fibres are, however, placed between the two ends, and the measurement taken in the middle of the seed represents the mode of the length. Such a measurement is taken seven times in the case of each plant, and the mean of these is adopted as the length of the staple of that plant. One more precaution is also taken. The seeds placed at the apex of the cells of the boll produce shorter hairs than those of other seeds of the same boll. This difference is marked in the late bolls which form the bulk of the last picking. All such seeds were excluded from the above measurements.[2]

[1] "The Development of Raw Cotton," page 184.

[2] It is possible that differences in staple may exist between the cotton lint from bolls produced in the different classes of branches. This matter is now under study.

Two hundred plants taken at random from the same field were examined and the results are shown in the following table :—

Length of staple Inches		Frequency
0·5	....	16
0·6	....	44
0·7	....	56
0·8	....	54
0·9	....	24
1·0	....	6

These figures show very wide variation. The mean is 0·722 inches, but figures distinctly lower than this are more common than those much higher. The standard deviation is 1·10 and the co-efficient of varilability is 1·57. As the length and the uniformity of the staple is one of the most important features in determining the value of a cotton it shows what a large field there is for improvement in both respects on an average *kumpta* cotton as now grown.

The attached curve (Fig. 13) illustrates the variation occurring in the staple of *kumpta* cotton.

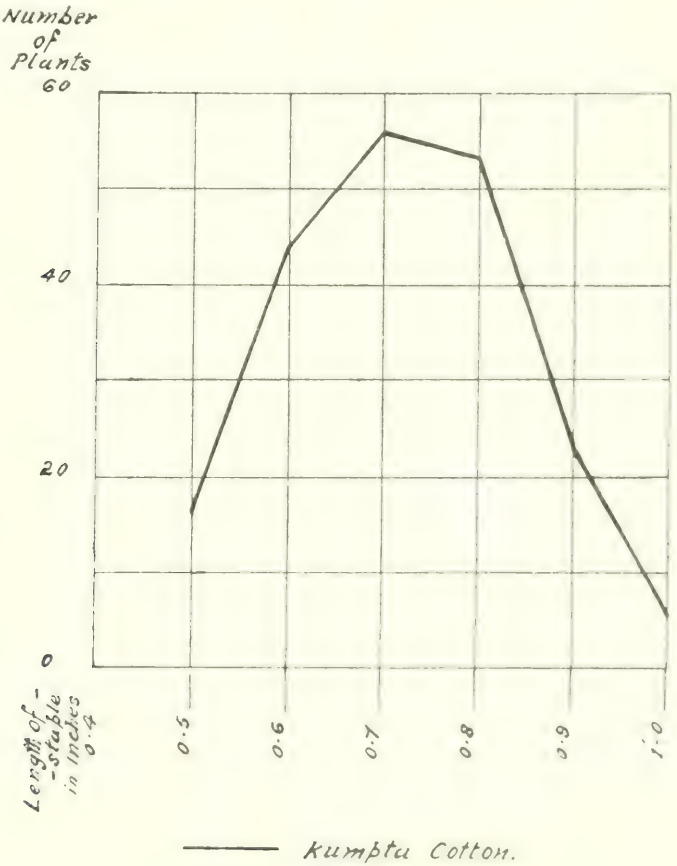


FIG. 13.

This study of the variation in a type of cotton, said to possess very stable characteristics, leads one to the conclusion that the stability of *kumpta* cotton, as ordinarily grown, has been much exaggerated. The numbers obtained, furthermore, make it almost certain that the variability noticed is due not to the ordinary variation in a single strain, but to the mixture of a number of strains. Take the ginning percentage, for example, and it will at once be seen that the curve obtained has four separate modes at 22, 24, 27 and 29—and the frequency curves representing other characters are in many cases also multimodal. Such multimodal curves inevitably suggest mixture, and in certain cases[1] it has been proved that they are due to the co-mingling of several different local races of a species.

If this is the case, the first step towards improvement will obviously be to determine the type or types which have the highest value to the grower, ginner, and buyer of cotton, select those strains of plants which most nearly conform to the various requirements, see whether these, when self-fertilized, breed true, and when they do so, to multiply them and gradually replace the present indefinite mixture of strains of very different economic value by one which combines the greatest number of desirable characters. The next chapter gives the result of a study of what is likely to be an ideal type of cotton for the *kumpta* tract.

V. Ideal type of cotton for the "kumpta" tract.

Yield. The type of cotton best suited for a tract must be greatly determined by the yield. The latter, therefore, must play an important part in all our considerations. The part which directly yields cotton is the boll. Consequently all gain in yield can only be secured by improvements in the boll. It is obvious that if nine bolls on each plant produce an yield of five hundred pounds of seed cotton to an acre, ten bolls on each plant will certainly increase the outturn by fifty pounds. Great attention must thus be paid to increase the number of bolls with the object of getting better yields.

Cotton plants vary very widely as regards their number of bolls. But the variations, though intrinsic, are greatly controlled by external influences. Individuals enjoying a slight advantage of plant food, moisture, or space, by virtue of their position, bear a greater number of bolls than their neighbours less favourably located. This, however, can be tested and the selections which owe their superiority to environment only can be rejected. The matter is, however, important, for, if the conditions on the testing plots are different (as

[1] De Vries. Ueber Curven—"Selection bei Chrysanthemum segetum." *Ber d, deutsch., Pot. Ges.*, Vol. XVII, p. 86.

is often the case) from those of the fields where the trial is to be ultimately made, even the tested strains may disappoint us altogether. Under such circumstances any one engaged in selection is likely to be deceived by the wrong forms and labour under misconceptions to no purpose.

To avoid all this trouble one must not be entirely guided by the number of bolls. This character, however, is often found intimately associated with others which are not influenced by environment to anything like the same extent. The study of such correlations, therefore, is very important and useful.

All annual cottons produce from the lower portion of their central stalk woody stems or limbs (monopodia). These vary in number and vigour in different varieties. The remaining portion of the central stalk bears at each node a small zigzag branch which directly supports the bolls (sympodia). At the base of these branches two vegetative shoots also appear, though somewhat rarely, which, like the monopodia above mentioned, branch before they bear the reproductive organs. We have thus three kinds of branches : (1) limbs or monopodia, (2) fruiting branches (sympodia), (3) axillary vegetative shoots. When all these three are present, the fruiting branches flower first, then the limbs, and lastly the axillary vegetative shoots. The limbs and axillaries thus prolong the period of flowering. Their extensive development very often causes the suppression of the fruiting branches, in which case the flowering also starts late. This is not, of course, necessarily a drawback, but in practice it is found that their extensive development in *kumpta* cotton exerts an injurious influence on the number of bolls, which is all important. The fruiting branches coming from the central stalk are in all cottons most productive. Those on the vegetative branches produce a large number of flowers but very few bolls. The following statement shows the productive capacity of the fruiting branches, limbs (monopodia) and axillaries in three types of *Gossypium herbaceum* :—

Name	Fruiting branch		Limb		Axillary	
	Average length of a branch	Average number of bolls on each	Average length of a branch	Average number of bolls on each	Average length of a branch	Average number of bolls on each
	Inches		Inches		Inches	
Kumpta, erect ..	2·31	1·11	13·01	0·50	6·01	0·02
Kumpta, bushy ..	1·63	0·74	17·21	0·32	11·42	0·07
Broach	1·02	0·48	21·81	0·53	14·71	0·18

From this table it will be noticed that one inch length of each type of branch carried the following number of bolls :—

Name	Number of bolls per one inch of branch		
	Fruiting branch	Limb	Axillary
1. *Kumpta*, erect ..	0·48	0·038	0·003
2. *Kumpta*, bushy ..	0·45	0·019	0·006
3. *Broach*	0·47	0·024	0·012

It is thus obvious that expenditure of energy in growing long limbs or axillaries in all three types is largely wasted, and that if a strain of equal vigour can be found which expends its energy in growing fruiting branches rather than limbs and axillaries, it will probably be a much higher yielding type of plant.

In the case of *broach* cotton the fruiting branches are greatly smothered by the vigorously growing limbs and axillaries, and this fact can be experimentally proved by removing the latter as soon as they appear, when the fruiting branches show marked increase in vigour and bearing. This effect is also clearly seen in early and late sown *broach* cotton at Dharwar. When the sowing is done early (in July) *broach* cotton becomes very vegetative, bearing weak and insignificant fruiting branches. If, however, the sowing is done late (in August) the rank growth is greatly checked and the fruiting branches show themselves well. The extravagance of the vegetative branches in the case of other cottons is marked on heavily manured fields where the plants yield very little in proportion to their size.

The fruiting branches, therefore, unless smothered or suppressed, yield a larger number of bolls than other parts. They also produce bigger bolls in many cases. In *kumpta* cotton I have found that nine bolls on the fruiting branches are normally equal to ten on the limbs and twelve on the axillaries. For these reasons our efforts to augment the outturn should, it would seem, be directed towards curtailing the vegetative growth and increasing the number of fruiting branches per acre, if this can be done without decreasing the general vigour of the plant. This, it would seem likely, might be done by growing an erect type as thick as it will conveniently stand. The individual plants of this type may not look as prolific as those of the bushy type when the latter have ample space. But the comparison which has always to be made is not in the yield per plant, but in the yield per acre. And hence in all such comparisons a row of plants sufficiently long must be taken as a unit.

Earliness. The cottons growing in the *kumpta* tract have, for *herbaceum* cottons, a relatively short growing period. They are sown at the end of August and their actual increase in size almost stops at the commencement of the cold weather in November. They further receive a check in March when the flowering suddenly ceases. Under these conditions the type best suited should be quick in growing and early in flowering. The ante monsoon showers falling in the months of April and May often spoil the later pickings. If the cotton, however, can be completely collected in two pickings the danger is greatly minimized.

In short, the plant which grows quickly, bears only fruiting branches, flowers early, and finishes its yield at the most in two pickings, is the ideal one for the *kumpta* tract, and it should be our endeavour to select such a type from the numerous strains found in the ordinary *kumpta* cotton, which, while possessing these characters, also gives cotton of staple and ginning percentage at least as high, if not higher, than that of the mixture now grown.

VI. Selections from "kumpta" cotton.

Having thus laid down (*see* previous chapter) the type of cotton plant which is likely to give a large yield of cotton, the problem of improvement might at first sight appear comparatively easy. But in cotton it is very often found that high-yielding types are not the most profitable to grow owing to their deficiencies in other directions. In fact it has been supposed by some that there is a natural antagonism between high yield, high-ginning percentage, and long staple. Though our results among *herbaceum* cottons do not entirely justify this position, yet the combination of these three qualities in one strain of cotton plant is very rare. It is even rare to find high-ginning percentage and long staple combined in the produce of one cotton plant. High-ginning percentage is more frequently combined with high yield in one and the same plant, and likewise long staple is not uncommonly found in a strain whose yield is high. If high ginning percentage is obtained at the cost of staple, the result is not at all desirable at least among *kumpta* cottons, for this tract is capable of yielding cotton of good staple and enjoys peculiar advantages for growing it. A type which gives a high yield and also has a long staple has, therefore, a better chance of success than any other, and it was to finding a type of this sort that our efforts were primarily directed.

We have, as a result of efforts to get as near as possible to the ideal type of cotton plant described in the previous chapter, and keeping in view the primary necessity of a high yield of a long staple cotton, now obtained three fixed strains of cotton by selection from the *kumpta* cotton grown at Dharwar, all of which have bred true through several generations. Each of these has advantages over the ordinary mixed type locally grown, and I will describe the origin and characters of each of these selected types.

"Dharwar No. 1."

The first of these selected strains, which I have termed "Dharwar No. 1," (Pl. IV fig. 1) is a selection from the erect plants of ordinary *kumpta* cotton, made because it conforms very largely to the ideal type I have described, in that it bears very few limbs (monopodia) and axillary vegetative branches. The attached frequency curve (Fig. 14) shows the difference in the number of limbs (monopodia) as compared with those on an ordinary mixed lot of *kumpta* cotton.

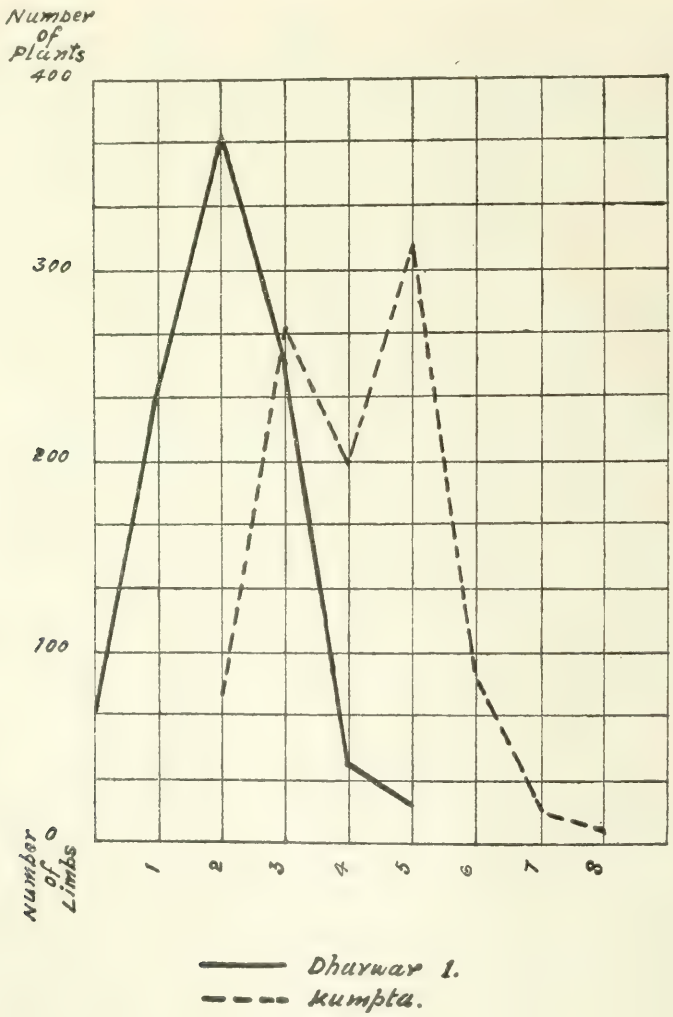


FIG. 14.

The difference is obvious. We have in this strain one with very much smaller number of monopodia and, moreover, one whose variability is very

Fig. 1. Typical plant of "Dharwar No. 1" Cotton.

Fig. 2. Typical plant of "Dharwar No. 2" Cotton.

PLATE IV.

much reduced. The character of the curve suggests that it is simple, and that the array is a homogeneous one.

The next point about this selection is its earliness. Not only does it, as would be expected, in the absence of many limbs, produce the greater part of its bolls in fruiting branches or sympodia, but these fruiting branches tend to appear early. The first of these fruiting branches appears, usually, at Dharwar, at the seventh or eighth node about eight inches from the ground, and the appearance of these branches is followed by rapid flowering. The accompanying curve (Fig. 15) showing the number of flowers on one hundred

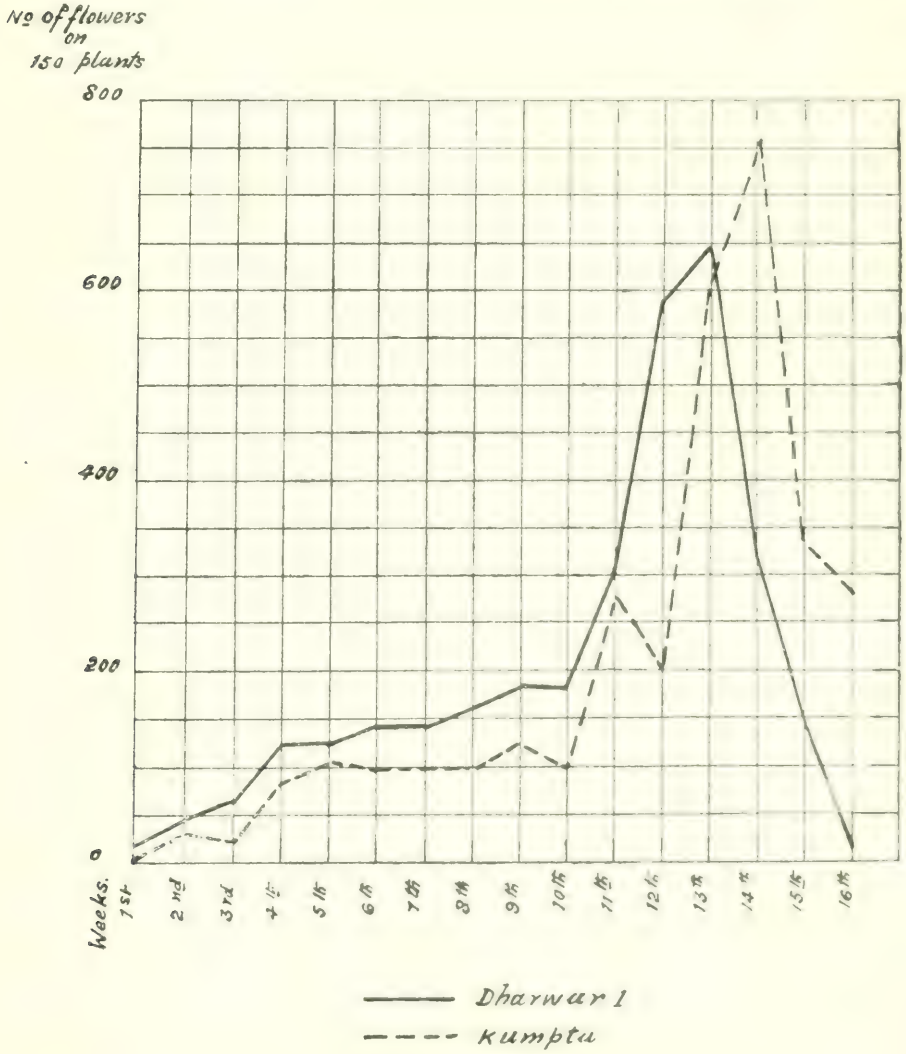


FIG. 15.

and fifty plants at various times after planting, as compared with those on a similar number of ordinary *kumpta* plants, illustrates this point.

Here it will be seen that while the cottons commence flowering at the same time, the number of flowers on the "Dharwar No. 1" is considerably higher, though the general course is the same. After the tenth week the "Dharwar No. 1" shows a rapid rise and reaches its maximum in the thirteenth week, and then rapidly falls, while flowers practically cease to appear after the sixteenth week. The ordinary *kumpta* cotton in cultivation reaches its maximum a week later than the selection under discussion, and then the fall is not so rapid. Flowers are, in fact, still being produced in large numbers in the sixteenth week, and afterwards. While, therefore, the "Dharwar No. 1" strain of cotton produces nearly all its flowers from the tenth to the fifteenth week, the *kumpta* as ordinarily grown goes on from the eleventh week until long after the sixteenth week, and, in fact, has a tendency to produce a very considerable proportion of its flowers in the latter part of its growing season.

This tendency to produce a large proportion of late flowers is a special disadvantage because, as the following table shows, the later the flowers are produced the greater the percentage of them which are shed and never develop into bolls. The figures were obtained by marking a large number of flowers which appeared during the months of December, January, February and March, and watching their later development both in the "Dharwar No. 1" and the ordinary *kumpta* cotton.

Month	"Dharwar No. 1"		"Kumpta" ordinary	
	Number of flowers marked	Percentage of flowers shed	Number of flowers marked	Percentage of flowers shed
December	120	16·7	190	52·7
January	2,370	14·8	2,500	36·0
February	2,480	69·0	5.210	79·9
March	50	100·0	20	100·0

These figures show the enormous increase in the wastage of flowers formed after January. Of flowers formed in March, in both cases none form bolls. They also show the very much larger proportion of flowers shed without forming bolls in the ordinary *kumpta* cotton than in the "Dharwar No. 1."

Another experiment to compare the proportion of flowers to bolls during 1917-18 and 1918-19 in the "Dharwar No. 1" and in ordinary *kumpta* cotton gave results shown in the following table :—

Name of cotton	1917–1918			1918–1919		
	No. of flowers on 100 plants	No. of bolls on 100 plants	Percentage of bolls to flowers	No. of flowers on 100 plants	No. of bolls on 100 plants	Percentage of bolls to flowers
"Dharwar No. 1" ..	2,332	1,562	67·0	2,800	1,921	68·6
Kumpta, ordinary ..	3,751	1,537	41·0	4,655	1,898	39·6

The ordinary *kumpta* cotton thus produces fifty per cent. more flowers than "Dharwar No. 1" when grown at Dharwar, but ripens a smaller number of bolls per plant. The number of bolls ripened is not, however, markedly greater, owing to the fact that the wider spacing (24 inches by 18 inches) adopted for the sake of the more bushy types mixed in the *kumpta* ordinary cotton was a positive disadvantage for the erect "Dharwar No. 1."

The "Dharwar No. 1" strain having been found to breed true to type has been tested every year since 1914 at Dharwar to ascertain its yielding capacity as against the ordinary *kumpta* cotton of the farms. The results have been as follows :—

Year	Yield of *kapas* per acre		Percentage increase given by "Dharwar No. 1"
	"Dharwar No. 1"	*Kumpta*	
	lb.	lb.	
1914	620	542	14·3
1915	612	564	8·5
1916	390	310	22·2
1917	547	440	24·3
1918	648	480	35·0
Average	563	467	20·9

"Dharwar No. 1" thus yields, on the average of five years, 20 per cent. more *kapas* per acre than ordinary *kumpta*. This increase in itself may or may not mean a corresponding gain in the nett profit. Whether it does so or not, depends on whether the increase in yield is accompanied by an equal

or larger ginning percentages, and by an equal or larger staple and equal strength and character of fibre. It is necessary, therefore, to determine how the selection compares with the ordinary *kumpta* cotton in these directions.

So far as the ginning percentage is concerned the comparison is given below :—

Year	Ginning percentage		Percentage increase given by "Dharwar No. 1"
	"Dharwar No. 1"	*Kumpta*	
1914	29·0	26·0	11·5
1915	28·0	26·0	7·8
1916	28·8	26·0	10·7
1917	28·0	24·7	13·3
1918	29·1	25·2	15·4
AVERAGE ..	28·5	25·5	11·7

The increase in ginning percentage is not very large, but it is distinct. Further it is observed that the ginning percentage of the "Dharwar No. 1" has remained very constant. Most of the samples either grown by myself or grown by others have ginned between 28 and 29 per cent. of cotton lint. This constancy of ginning percentage enhances the commercial value of the *kapas* of "Dharwar No. 1," for normally the ginning percentage of *kumpta* cotton varies a good deal.

The comparative constancy of the ginning percentage is shown by the following figures intended to show the variability of different plants in this character :—

Number of plants examined	..	..	..	..	100	plants
Ginning percentage 26	..	..	..	..	3	,,
,, ,, 27	..	..	..	..	18	,,
,, ,, 28	..	..	..	..	56	,,
,, ,, 29	..	..	..	..	12	,,
,, ,, 30	..	..	..	..	10	,,
,, ,, 31	..	..	..	..	1	,,

The distribution is shown in the attached curve (Fig. 16), which may be compared with that for the *kumpta* crop in general shown in Fig. 10.

The average ginning percentage is 28·1 which is identical with the mode. The variation is narrow. The standard deviation is 0·301 and the co-efficient of variability is 0·0107.

This gain in ginning percentage may be due to a greater development of lint or to a decrease in the weight of the seed. It is not, however, due to

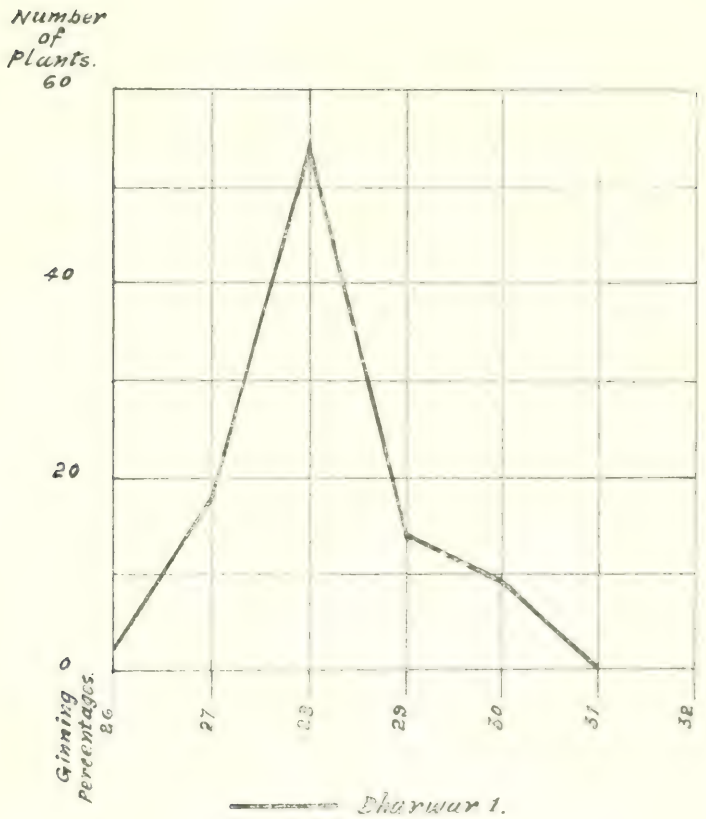


FIG. 16.

the latter cause—a decrease in the weight of the seeds—for the following table shows that the seeds have, each year, been slightly heavier than those of the ordinary *kumpta* crop grown on the same farm:—

Year	Weight of 100 seeds	
	"Dharwar No. 1"	*Kumpta*
	Grammes	Grammes
1916	5·320	5·070
1917	5·730	5·307
1918	5·480	5·240

Perhaps the chief interest in the present selection, "Dharwar No. 1," is in its staple, for it is the final result of selection originally started in *kumpta* cotton in 1904, specially with the view of improving the staple. For the first six years all plants carrying good staple were taken collectively, but in

1910 the mass selection was discontinued and unit selection from the plants which appeared to have the largest combination of useful properties, and which bred true to type when self-fertilized, was adopted. In 1912 the erect strains of *kumpta* were found to be superior in yield to the bushy type and selection was principally continued chiefly with this type. The main object was still the selection of the best staple cotton from the ordinary *kumpta*, but attention now was also directed to the ginning outturn. The final selection of "Dharwar No. 1" was made in 1913, as the type seemed to possess a combination of erect character of plant, high yield, high-ginning percentage, and good staple.

One of the special features of value in "Dharwar No. 1" is the evenness of the staple. The length of the cotton fibres on the seeds of two hundred plants was determined by the method described on page 248 and the following are the results :—

Total number of plants examined	200	
Staple of 0·7 inch	0	plants
„ „ 0·8 „	24	„
„ „ 0·9 „	72	„
„ „ 1·0 „	84	„
„ „ 1·1 „	20	„

The attached frequency curve (Fig. 17) shows the position, and should be compared with the curve for ordinary *kumpta* shown on page 249 (Fig. 13).

The mean is 0·95. The standard deviation and the co-efficient of variability are 0·0306 and 0·034 respectively.

The staple of the "Dharwar No. 1" has remained ever since distinctly higher than the ordinary *kumpta* cotton, and its strength is also good. The staple measures about one inch, and is, of course, more uniform. The following are valuations and remarks very kindly made by the valuers of Messrs. Tata and Sons, Bombay, for each year from 1914 to 1918.

Year	Value of lint per candy of 784 lb.		Remarks of valuers
	"Dharwar No. 1"	*Kumpta*	
	Rs.	Rs.	
1914	245	230	In every respect "Dharwar No 1" is superior to *kumpta*.
1915	350	335	Silky and better than *kumpta*, all round. Will spin up to "35."
1916	550	530	Better than *kumpta* in every respect, in cleanliness, in length and in strength of fibre.
1917 ..	950	900	Nice stapled cotton. Value equivalent to *surat*.
1918	640	625	Is decidedly superior in length of staple to ordinary *kumpta*.

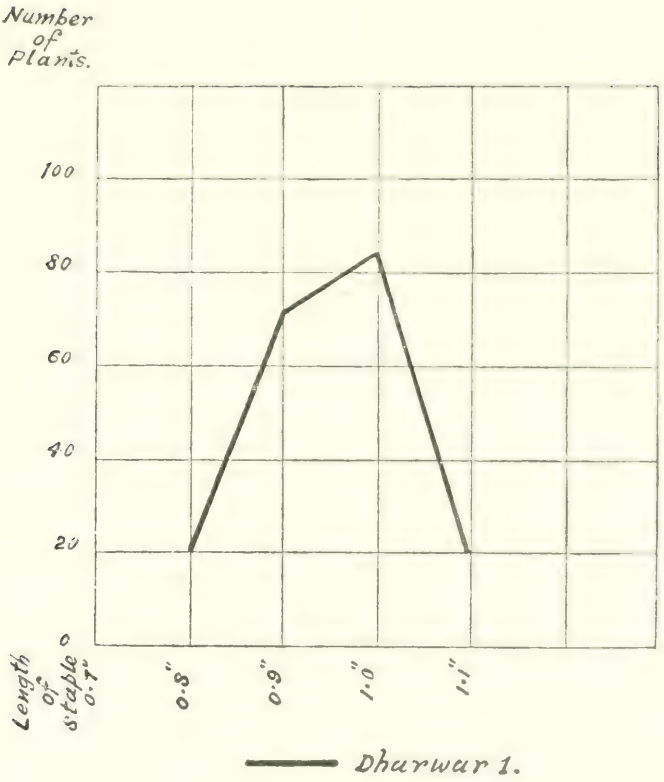


FIG. 17.

The 1918 cotton was submitted to the Cotton Contracts Board, Bombay, and their opinion, very kindly furnished, is as follows: "The sample in spite of some nappiness and want of silkiness is a very excellent cotton which if it continues to maintain its present characteristics and its superiority in yield should have a great future before it. As compared with good *kumpta* the sample is fine and possesses an excellent strong staple. It is valued at Rs. 30 to 40 per *candy* better than good *kumpta*."

We have thus a cotton which yields better, gins higher, and possesses a staple which is larger and stronger than the ordinary *kumpta*, and is, therefore, desirable in every way. It has now spread over 1,000 acres in 1918, and is being distributed to an area of 6,000 acres in the *kumpta* area (in 1919). The characters are being maintained by fresh selection from protected and self-fertilized plants every year, and it seems probable that it will have a considerable future in the area now growing *kumpta* cotton.

"Dharwar No. 2."

While from the point of view of general improvement of *kumpta* cotton, "Dharwar No. 1," as already described, may be considered to possess the best combination of characters yet discussed, it may be of value to describe shortly certain other strains which have been isolated and kept pure for a number of years. These will clearly show to what extent *kumpta* cotton as usually known is a mixture of types of very different agricultural and commercial value.

"Dharwar No. 2" is one of these. When the fact was first recognized that there exist erect and bushy strains in *kumpta* cotton a number of plants showing the latter character (bushiness) were selected. The progeny of these plants were tested, and the best among them, which bred true, retained for trial and study.

This has been continued under the name "Dharwar No. 2." As with other bushy plants, this type bears, in general, a large number of limbs and axillary vegetative branches, which are more or less crowded about the central stalk. The type of plant is well shown on Plate IV (Fig. 2).

The results of cultivation of this type compared with the ordinary *kumpta* cotton are shown in the following two tables :—

1. *Yield of "kapas."*

Year	"Dharwar No. 2"	*Kumpta*	Percentage decrease of "Dharwar No. 2" from *Kumpta*
	Kapas yield per acre lb.	*Kapas* yield per acre lb.	
1915 ..	520	606	14·2
1916 ..	485	487	0·4
1917 ..	440	547	19·7
1918 ..	460	480	4·2
AVERAGE ..	476	530	9·6

2. *Ginning percentage.*

Year	"Dharwar No. 2"	*Kumpta*	Percentage increase of "Dharwar No. 2" from *Kumpta*
	Ginning percentage	Ginning percentage	
1915 ..	29·0	26·2	10·7
1916 ..	28·0	26·1	7·3
1917 ..	27·9	26·2	6·5
1918 ..	29·3	25·2	16·2
AVERAGE ..	28·5	25·9	10·1

These results indicate that "Dharwar No. 2" cannot compare with ordinary *kumpta* and even less with "Dharwar No. 1" in point of yield, but that the ginning percentage is high, equal in fact to that of "Dharwar No. 1." So far as yield is concerned, the *kapas* produced per acre is almost equal to that of *kumpta* in two years out of four, and it was suggested to me that the reason for its failure in the other years was the absence of the most favourable conditions of plant food and moisture. That this was not the case was proved by growing it under exceedingly favourable conditions at Gokak, when it showed the following yield and ginning percentage in comparison with "Dharwar No. 1."

Name of cotton	Yield of *kapas* per acre	Ginning percentage
	lb.	Per cent.
"Dharwar No. 1 ..	1,210	28·4
"Dharwar No. 2" ..	1,165	27·0

The staple of "Dharwar No. 2" was also inferior, even to ordinary *kumpta*. Valuations by Messrs. Tata Sons & Co. of the lint, per Bombay *candy* (784 lb.) in 1915 and 1916 were as follows:

Year	"Dharwar No. 2" Value per *candy*	*Kumpta* Value per *candy*
	Rs.	Rs.
1915	315	430
1916	475	515

This selection from *kumpta* cotton appears, therefore, to have no future. It may possibly form the basis of a future crossing, and so the pure line stock is being maintained. Beyond that, its description is only valuable as showing the character of one of the inferior types included in the ordinary mixture known on the market as *kumpta* cotton.

"*Dharwar No. 3.*"

This selection from *kumpta* cotton has a long history dating back to 1901. In that year a cross between two strains of *kumpta*, neither of them in

pure line cultivation, was made at Kirkee by Mr. Gammie. The resulting seed was sent in 1904 to Surat, where prolific plants were deliberately recrossed. This double cross between different strains of *kumpta* was grown at Surat till 1908, when it was finally transferred to Dharwar.

The work at that time was not conducted with real precision, and the produce was only further selected by mass selection on the basis of ginning percentage and better staple. The resulting seed, which was given the name of "*kumpta* cross," gave good promise of success from the first, at Dharwar. The staple was considered better than that of ordinary *kumpta*, and it was noted as being similar to *broach* cotton in style. In subsequent trials, the yield was, however, found to be lower than that of *kumpta* : while the ginning percentage and staple maintained more or less their superiority. By 1911, however, it was evident that the type was not pure, that it was rapidly losing its special characters of high-ginning percentage and staple, and that to obtain any satisfactory and reliable results individual selection would have to be carried on. The following figures which are interesting as showing how rapidly "deterioration" took place, indicate how the characters changed, when only mass selection was employed between 1908 and 1913 :—

Year	"KUMPTA CROSS"			"KUMPTA"		
	Yield of *kapas* per acre in lb.	Ginning per cent.	Value per *candy*	Yield of *kapas* per acre in lb.	Ginning per cent.	Value per *candy*
			Rs.			Rs.
1908	624	27·1	275	..	..	..
1909	431	25·4	300	..	..	..
1910	516	30·3	300	546	25·5	305
1911	438	26·1	315	360	23·8	290
1912	586	28·0	305	789	24·8	290
1913	456	24·6	235	503	23·3	235
AVERAGE	508	26·9	288	549	24·3	280

As it was obvious that the type had lost its special characters, individual selection was again begun in 1913, and the seed has been maintained in this manner since. The originally selected seed, self-fertilized, has been found to breed true, and has now formed a very useful type of *kumpta* cotton, which I

Fig. 3. Typical plant of "Dharwar No. 3" Cotton.

Fig. 4. Typical plant of "Dharwar No. 4" Cotton.

PLATE V.

term "Dharwar No. 3" (Pl. V, fig. 1). The yield, ginning percentage and value are given below :—

Year	"Dharwar No. 3"				"Kumpta"			
	Yield of *kapas* per acre	Ginning percentage	Yield of lint per acre	Value per *candy* (784 lb.)	Yield of *kapas* per acre	Ginning percentage	Yield of lint per acre	Value per *candy*
	lb.		lb.	Rs.	lb.		lb.	Rs.
1914 ..	532	33·0	175	245	542	27·0	146	330
1915 ..	528	31·2	165	350	564	26·1	147	335
1916 ..	540	30·2	163	540	626	24·3	152	530
1917 ..	420	33·2	139	900	440	24·7	108	900
1918 ..	432	33·1	143	..	480	25·2	120	..
AVERAGE ..	490	32·1	157	509	530	25·4	134	498

From these figures it will be seen that it has a considerably higher ginning percentage even than "Dharwar No. 1," that it has a market value at least as high or higher than ordinary *kumpta*, and that though its yield of *kapas* is low, its yield of lint per acre is generally higher than ordinary *kumpta*. Thus though the yield of *kapas* is less, the higher ginning outturn compensates for this loss of yield.

On the whole, however, it is not equal in value to "Dharwar No. 1" as the following average figures show :—

Name of cotton	*Kapas* per acre	Ginning percentage	Lint per acre	Average value per *candy* 1914 to 1917
	lb.		lb.	Rs.
"Dharwar No. 1" ..	563	28·5	160	524
"Dharwar No. 3" ..	490	32·1	157	509

Though these figures are not absolutely comparable, they show, I think, the position with regard to the two strains. If anything, the difference of yield should be more in favour of "Dharwar No. 1."

"Dharwar No. 3" is bushy in its habit of growth. It flowers late and this lateness is a disadvantage, especially in years when the rain during

October and November is heavy. The cotton, however, is an improvement on the ordinary *kumpta*, and there has grown up, in the transition tract of the Dharwar District, a considerable demand for its seed.

VII. Crosses of "kumpta" cotton with "ghogari" cotton.

Ghogari cotton is a variety of *Gossypium herbaceum* well recognized by the trade and by the cultivators, which originated so far as we know in the north of the Broach District in Gujarat. It has a very high-ginning percentage, often 40 per cent. or over, and this is its sole advantage. Its staple is short and rough, its yield is certainly not higher than that of other varieties of *herbaceum* cotton, and it has no special virtue of vigour or healthiness. The very large ginning percentage is its only advantage, but if this quality can be combined by crossing with *kumpta* cotton, without causing deterioration of the latter in other directions, a considerably better type will have been produced than any at present existing.

This was the principle on which my predecessors in cotton-breeding work based their crosses of *kumpta* with *ghogari* originally made at Dharwar in 1905. The care bestowed on keeping them pure later on was such that the value of the crosses was almost lost. In the first generation all good plants were picked collectively, but from the second generation unit selections were made for yield, for high-ginning, and for good staple.

For long, these selections were unsatisfactory as they continued to split, but finally two strains with fixed characters which, when self-fertilized, breed true were obtained, one in the year 1913 and the other in 1914. These have been called respectively "Dharwar No. 4" and "Dharwar No. 5." These strains have the following characters :—

1. "Dharwar No. 4" is an intermediate type between the erect plant and a truly bushy one (Pl. V, fig. 2). It, however, produces no axillary vegetative branches. It flowers early like the *kumpta* parent, yields well, and gins much better than ordinary *kumpta* cotton. The staple is, however, short.

2. "Dharwar No. 5" is bushy in habit of growth, and late in flowering. Its yield is consequently small, but its ginning percentage is high, and its staple is good. It is, in fact, a very promising cotton, and in our hands has proved more profitable than *kumpta*.

The yield per acre of *kapas*, and of lint, their ginning percentage, and the value per candy of the lint, as compared with that of ordinary *kumpta* cotton, is shown in the following tables :—

1. *Yield of "kapas" per acre.*

Year	"Dharwar No. 4"	"Dharwar No. 5"	*Kumpta*
	lb.	lb.	lb.
1914	..	365	497
1915	566	395	420
1916	573	596	548
1917	448	392	440
1918	464	380	480
AVERAGE ..	538	425	475

2. *Yield of lint per acre.*

Year	"Dharwar No. 4"	"Dharwar No. 5"	*Kumpta*
1914	..	135	122
1915	213	142	100
1916	186	205	134
1917	147	147	115
1918	155	139	120
AVERAGE ..	175	153	118

3. *Ginning percentage.*

Year	"Dharwar No. 4"	"Dharwar No. 5"	*Kumpta*
1914	..	37·0	24·7
1915	32·1	36·2	24·0
1916	32·6	34·9	24·5
1917	33·0	37·5	26·2
1918	33·6	36·7	25·2
AVERAGE ..	32·8	36·4	24·9

4. *Value per candy (784 lb.) (Computed with the market price of kumpta cotton at the time).*

Year	"Dharwar No. 4"	"Dharwar No. 5"	*Kumpta*
	Rs.	Rs.	Rs.
1915	300	340	335
1916	480	520	515
1917	870	965	900
1918	635	645	625

From these figures it will be seen that "Dharwar No. 4" yields the largest yield per acre of *lint*, but the staple is undesirable, and hence the strain is one which in its present form it would not be wise to introduce. "Dharwar No. 5" yields less *kapas* per acre than ordinary *kumpta*, but its higher ginning percentage, a percentage in fact altogether unprecedented in a *kumpta* cotton, gives it a great advantage in the matter of lint. As its staple is also good, this strain seems to have advantage which may lead to its general usefulness in some parts of the *kumpta* area. For general introduction and use I prefer the selection known as "Dharwar No. 1," but "Dharwar No. 5" may surpass it as a commercial strain in certain cases, and in any case it will form an excellent basis for crossing with a high quality, high-yielding type, which suffers from having a low ginning percentage.

Each of the five strains of cotton produced by selection from *kumpta* ("Dharwar Nos. 1, 2 and 3") or by selection out of a *kumpta-ghogari* cross ("Dharwar Nos. 4 and 5") possess certain special characters (Plates VI and VII), which may now be tabulated side by side. In determining these figures, however, it may be stated that they have been obtained from the cottons growing on similar soil, side by side, at Dharwar. All grew vigorously there. The special characters of each of these strains are as follows :—

Dharwar No. 1. An erect and early type, suited for the whole of the *kumpta* tract. Staple better than ordinary *kumpta*.

Dharwar No. 2. A bushy type. Staple not desirable.

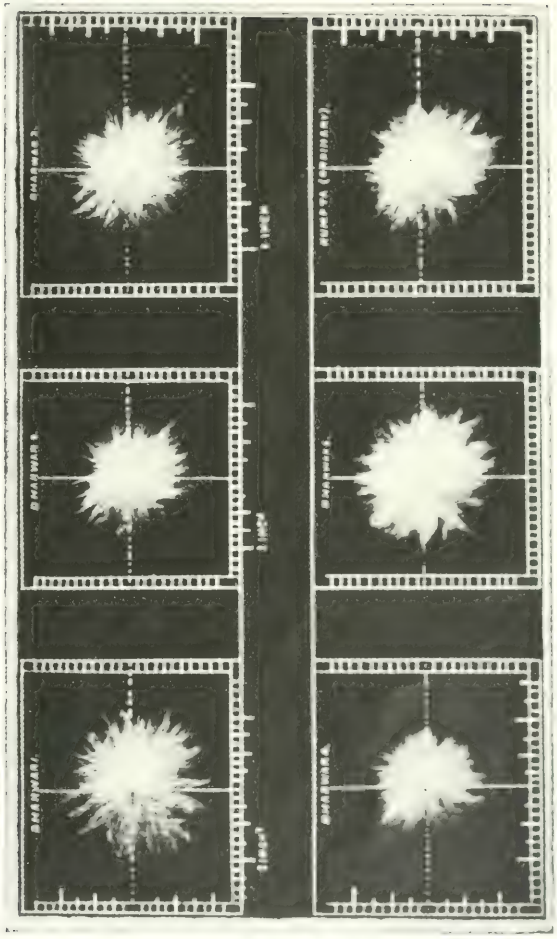
Dharwar No. 3. A bushy type, which has proved itself suitable for the transition tract. Staple better than ordinary *kumpta*.

Dharwar No. 4. A semi-erect and early type. Staple short.

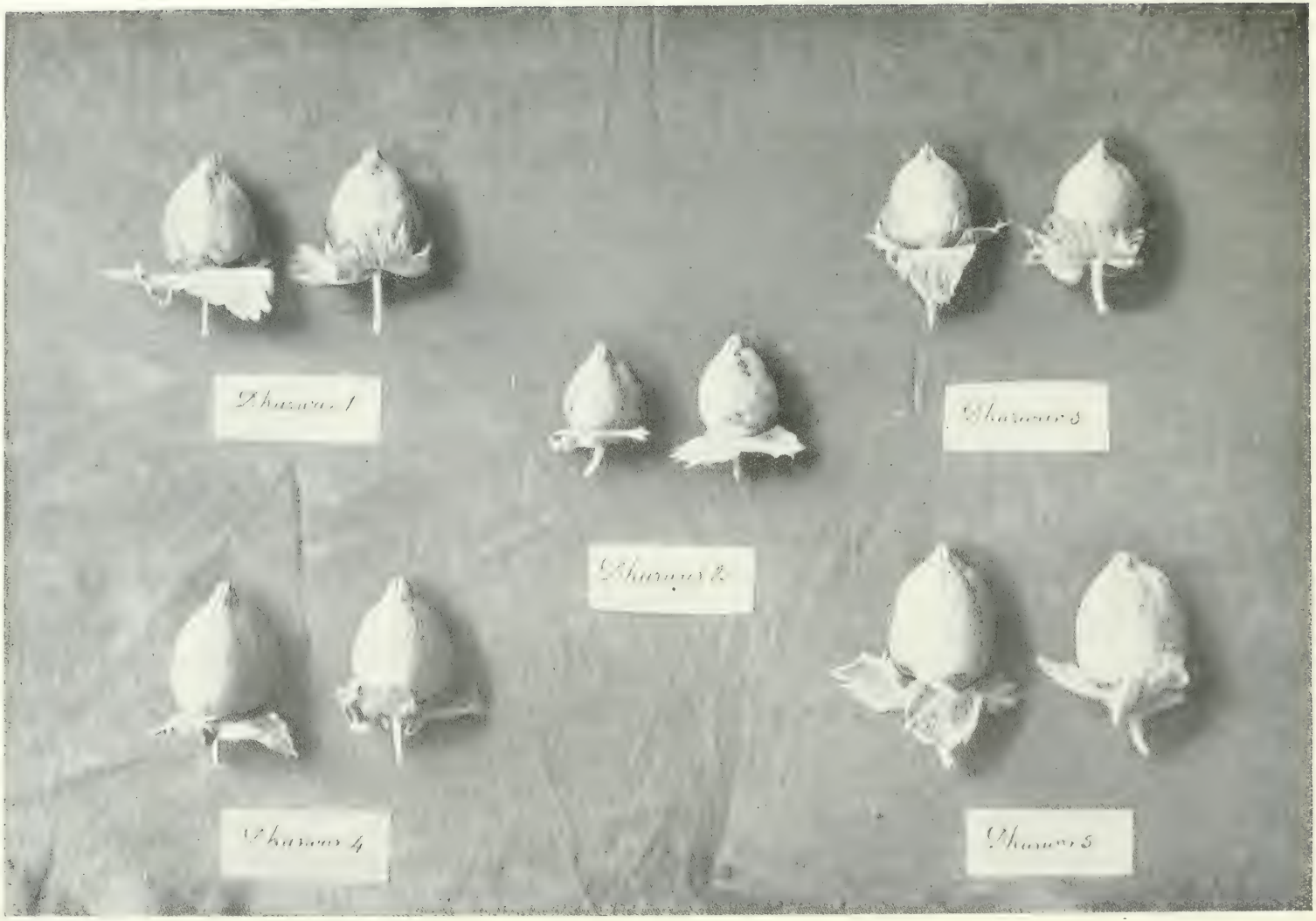
Dharwar No. 5. A bushy and late type, but with very high-ginning percentage and good staple.

The average characters of each type in a series of years of cultivation are as follows. (The standard of comparison in the last two columns is *kumpta* cotton at Rs. 500 per *candy*) :—

Name of cotton	Yield of *kapas* per acre	Ginning percentage	Yield of lint per acre	Value per *candy*	Value of lint per acre
	lb.	Per cent.	lb.	Rs.	Rs.
Ordinary *kumpta* ..	467	25·5	119	500	75
"Dharwar No. 1" ..	563	28·5	160	526	107
"Dharwar No. 2" ..	476	28·5	135	349	60
"Dharwar No. 3" ..	450	32·1	157	511	102
"Dharwar No. 4" ..	538	32·8	175	470	105
"Dharwar No. 5" ..	425	36·4	153	520	101



Staples of "Dharwar Nos. 1, 2, 3, 4, and 5" and of ordinary *Kumpta*.



Bolls of "Dharwar Nos. 1, 2, 3, 4, and 5" Cottons.

PLATE VII.

It is obvious, from all these results and from the descriptions of the types which have been isolated from *kumpta* cotton, that we have in this cotton as it is usually grown, a mixture of a considerable number of strains differing in character of plant, in yield, in the ginning percentage of the *kapas* produced, and in the quality of the cotton lint. It is clear too that some at least of these strains breed true, and that, hence, it is possible by simple isolation of existing strains to get types which are better adapted to the special requirements of the cultivators and the trade than the mixture at present existing. It is clear, furthermore, that the qualities of earliness, yield, ginning percentage and staple are really in no way opposed to one another, and that there is no essential reason why an early cotton, with high yield, high ginning percentage, and good staple should not exist. These qualities are most nearly combined, so far as we have gone at present, in the cotton described as "Dharwar No. 1." But the existence of pure line strains of a cotton having all the characters of *kumpta* cotton, including long staple, but with a ginning percentage in pure line cultivation of over 36 per cent. by isolation from a simple cross with *ghogari* cotton, would lead to the belief that it will be possible to go much further and combine in one strain this ginning percentage with the other desirable qualities occurring in "Dharwar No. 1." This will be the object of the next stage of the work on *kumpta* cotton.

APPENDIX.

The supposed deterioration of types of cottons in cultivation.

During the course of the work described in the foregoing paper, the question frequently arose as to whether a type of cotton will deteriorate when grown in conditions which are not those in which it is normally found. The specific case was that of the successful attempt made some fifteen years ago to introduce *broach* cotton cultivation into the *kumpta* tract. That cultivation has been very successful in a limited area. The principal advantage of the *broach* type has been, however, the greater ginning percentage of the *kapas* combined with a staple equal to *kumpta*, and a lint very much better in colour and general appearance. It has been found, however, that unless fresh seed is constantly introduced from Gujarat, the cotton grown rapidly loses its advantages. The ginning percentage declines, the colour is lost. This has been ascribed to deterioration of the cotton owing to its being grown under conditions to which it is not accustomed. It may, however, equally well be due to cross fertilization with the local cotton. It is obvious that an examination of this case might give results of wider interest in studying the general question of deterioration.

The actual change in the ginning percentage of *broach* cotton *kapas* on growing at Dharwar is shown in the following table. Fresh seed was obtained every year, but at the same time the Dharwar-grown seed was also sown. Thus we can give the ginning percentage of seed which has been grown at Dharwar for almost any number of generations up to thirteen. The results are quoted for three years, 1914, 1915 and 1916:—

Generation	Ginning percentage during		
	1914	1915	1916
1st ..	32·7	32·1	33·5
2nd ..	32·7	32·5	32·4
3rd ..	32·4	34·1	32·0
4th ..	32·6	33·5	32·1
5th ..	28·0	32·9	30·6
6th ..	28·7	27·0	30·0
7th ..	29·1	28·1	27·7
8th ..	28·0	28·6	28·4
9th ..	..	27·5	28·2
10th ..	29·2	..	28·2
11th ..	29·2	28·4	..
12th ..	..	28·4	..
13th ..	..	..	28·7

From these figures it will be seen that the fall in ginning percentage is gradual to a definite limit, which is a little higher than that of the local *kumpta* cotton. The biggest drop, however, takes place in the fifth or sixth generation.

If this deterioration is due to crossing, then if the cotton can be self-fertilized, it ought not to take place. A series of generations starting from 1913 were, therefore, self-fertilized, and the effect on the ginning percentage of the following generations determined.

The method adopted was as follows: A number of plants were taken at random in each crop, and all the flowers of these plants were self-fertilized. The selfing was done by putting small iron rings on the flower buds so as to completely prevent the opening of the petals. The seed thus produced by self-fertilization was taken for the next sowing, and was hand-dibbled on an area of about one-twentieth of an acre. This supplies sufficient seed for trial on a field scale.

The result of applying this method to the *broach* cotton for a number of generations, starting from seed imported in the several years since 1913, is shown in the following table. The critical measurements were made in the three successive years 1916, 1917, and 1918.

Generation	Ginning Percentage during		
	1916	1917	1918
1st ..	33·6	36·1	37·2
2nd ..	32·5	34·0	36·7
3rd ..	34·1	34·0	35·4
4th ..	34·1	35·0	34·9
5th ..	..	34·5	36·1
6th ..	..	..	36·4

The percentages vary, but no fall in ginning percentage is indicated in the older generations. And it would seem to dispose completely of the idea that the continued growing of *broach* cotton in a tract like the Dharwar District to which it is unaccustomed is itself a cause of deterioration in the matter of ginning percentage. It is perhaps not entirely due to cross-fertilization, though the fact that cross-fertilization takes place in cotton is now established beyond all doubt. All the Indian varieties cross easily and the amount of natural crossing is considerable (up to six per cent.), when various varieties are grown in adjoining plots. The deterioration in large scale cultivation may not be entirely due, however, to this cause. There is also the question

of mixing seed in gins and elsewhere, and the persistence of self-sown plants in fields where cotton is continuously grown. But the evidence is very strong that we have not to fear a serious alteration in essential characters simply because of removal to different conditions like those of Dharwar, in the case of *broach* cotton.

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